DECEMBER 1959

Power Engineering

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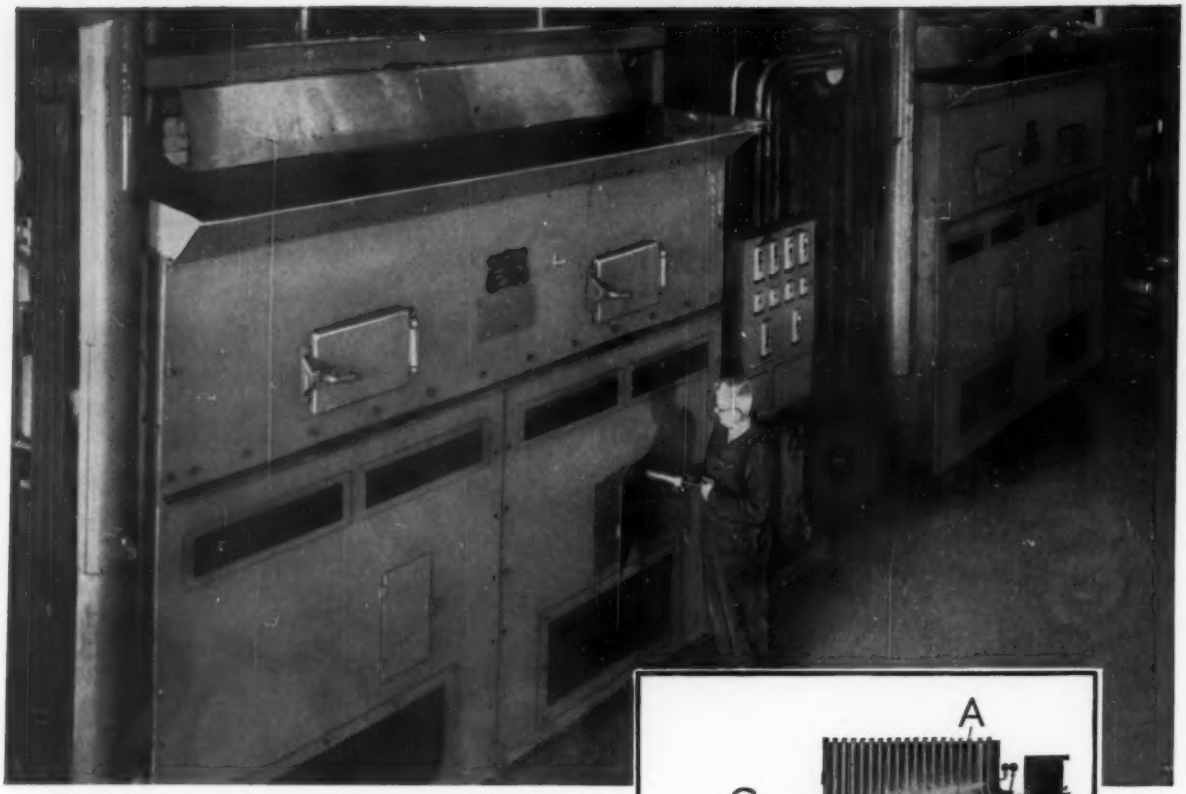

The only preventive maintenance required on a Vibra-Grate Stoker is for a mechanic to grease it every three months at four points on the front.

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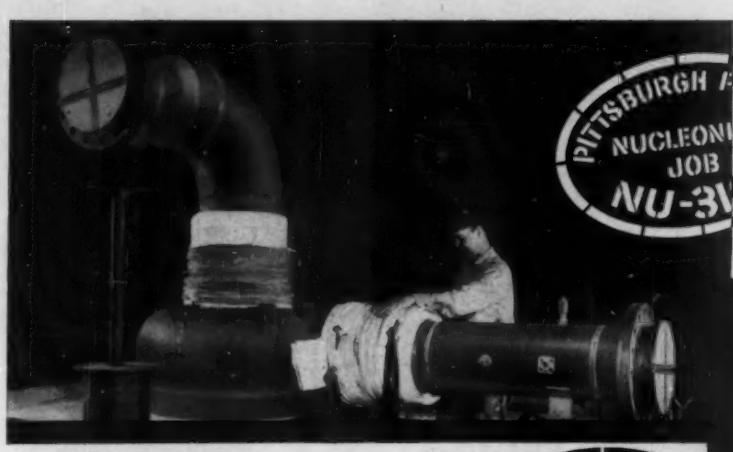
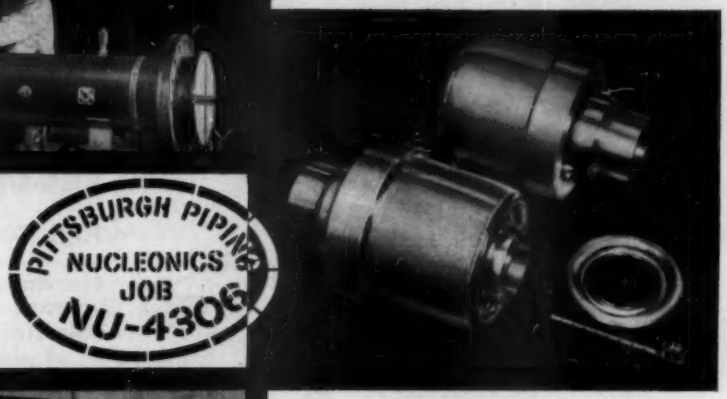
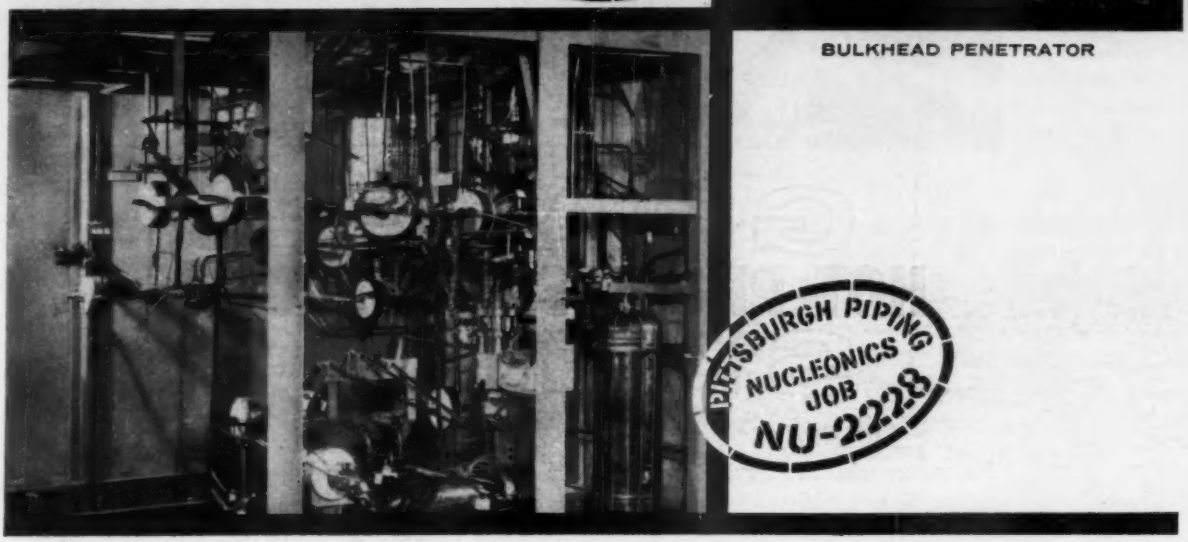


VOLUTE ASSEMBLY



BULKHEAD PENETRATOR

STAINLESS STEEL LOOP



Fabricated by Pittsburgh Piping for Nucleonics

These jobs demonstrate the variety of nucleonic piping work done in our shops. The volute assembly, shown in intermediate stage of manufacture, is fabricated of 14" and 16" Schedule 160 piping materials. The bulkhead penetrator, one of a group, is notable for an unusual method of welding dissimilar metals. The complex test loop requires skillful welding of stainless steel piping materials, and precise assembly of hundreds of components. We are equipped and staffed to do similar jobs for you. Telephone, or write and our representative will call. Or, we will be glad to have you visit our plant.

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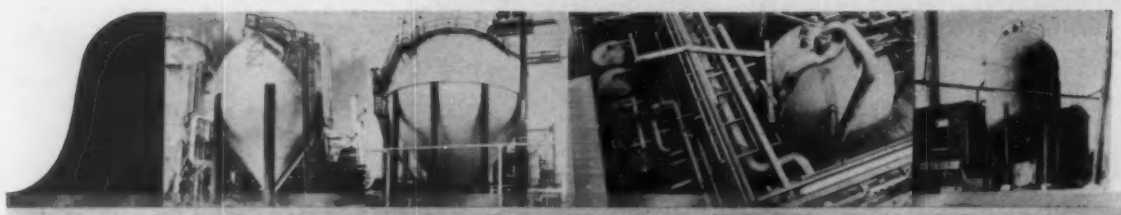
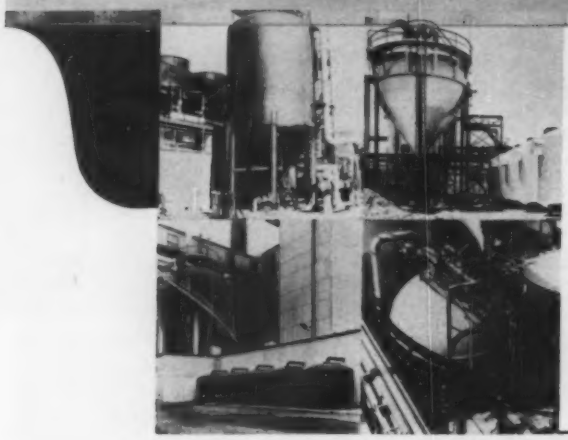


Designed to Handle—



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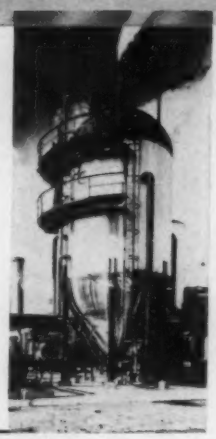

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Change of Address: Send to POWER ENGINEERING, Circulation Division, Barrington, Illinois. Please supply your position title, company name, company address. Request must reach us by 15th of month to make the change effective with the following month's issue.

Subscription Information: Published monthly, price in U.S. and possessions $10 per year; in Canada $11 per year; other countries $12 per year; single copies $1.

Indexed in the Industrial Arts Index and the Engineering Index on file in public and many private libraries.

Microfilm edition: Request prices from University Microfilms Inc. Ann Arbor, Mich. All volumes since 1948

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PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL PLANTS

ENGINEERS' PREVIEW

HOW FAR AWAY is the industry from universal acceptance of the automatic plant concept?

Results of a brain-storming excursion into the realm of probability with General Electric Co officials indicate that, while electric utility capacity continues to double every ten years, automation of large generating units will probably more than quadruple within the next four, with at least ten such installations going into operation in 1963, and with more than half of all new capacity by 1972 being under computer control.

LAST APRIL, first public announcement was made of Louisiana Power and Light's Little Gypsy station as the world's first completely automatic generating station. Shortly thereafter, rumblings emanating from the West Coast indicated that another such installation was in the offing. Within a matter of months, announcement was made concerning units 3 and 4 at Southern California Edison's Huntington Beach station, which will also be of the push-button variety.

Recognizing an important trend in the making, we sent Associate Editor Jeff Hunnicutt to talk to anyone and everyone even remotely concerned with the automation of large generating stations.

In more than 15,000 air miles and 140 personal interviews, Hunnicutt talked with 37 electric utility groups, 103 manufacturers of boilers, turbines, computers, controls and allied equipment, as well as 11 engineering and construction groups in 35 states.

Result is the forthcoming January, 1960 issue of POWER ENGINEERING in which, in a big presentation called Changing Shapes in the World of Power, we will define, analyze and coördinate those forces and factors which today are changing the understanding of automation in the power plant.

AUTOMATION is truly many things to many people. Ask any 20 people in the power field what automation means to them and quite likely you will get 20 widely varying answers. To Bill Key of Brazos Electric Power Coöperative in Waco, Texas, it means the station heat rate recorder-integrator in their new 33-mw station in Weatherford, Texas. To Philip Sporn of American Electric Power Co, it means the experiment that failed 20 years ago. To Bill Hess and John Horton of Louisiana Power and Light, it means Little Gypsy exemplified. To Commonwealth Edison, Pacific Gas and Electric and a host of others, it means an electronic brain that will indicate and dispatch the next most economically desirable block of generating capacity.

IT IS NOT SURPRISING that considerable controversy exists as to proper methods of approaching the automatic plant. Indeed, it would be most unusual if this were not the case in so dynamic a movement.

For example, some prominent authorities extol the merits of analog computers for the operation. Equally vocal and authoritative is another group which says that automation, in the sense intended and sought, is possible only with a general purpose digital computer.

Question of whether to monitor carbon dioxide, oxygen or total air in flue gas for automatic control purposes is guaranteed to start a spirited discussion in any group of power engineers concerned with the subject.

Without taking sides, POWER ENGINEERING in January will attempt to define all areas and concepts, describe the systems available, and lay a basic foundation for understanding computer operation.

NEITHER LITTLE GYPSY nor Huntington Beach, by the way, will be the nation's first automatic station, although they will be the first manifestations of the state of the art of modern control concepts.

An automatic station was built in

the 1920's by Great Western Electric Co (later absorbed by Pacific Gas and Electric Co). Known as Hunter's Point No. 1, it is still in operation. It was originally installed as back-up for an extensive hydroelectric system, and operation was automatically triggered by a drop in system frequency.

Another push-button unit was installed in 1940 in the Windsor Station of Ohio Electric Co but was later abandoned as unsatisfactory. Absence of critical controls hardware due to the war then in progress may have in some measure contributed to the situation. However, T. T. Frankenberg of American Electric Service Co says that "the control system consisted of approximately 140 drop-type relays, each with an availability factor of 99.9 per cent, and each dependent in turn upon successful operation of all up-stream relays; the station was always in trouble."

ADVANTAGES to be derived from automation must stem from the less obvious sources. No one anticipates any wholesale reduction in operating personnel, and any attempt to justify the movement on those grounds is doomed to failure.

If, as one consultant stated, an operator can be "capitalized" at $40,000 annually, elimination of all operating personnel still would not make the automatic operation sufficiently attractive, economically, with that as the sole criterion.

Optimum generating modes, reduced maintenance with greater reliability, greater longevity of major equipment, eventual lowering of major equipment costs: all must contribute to make automation pay.

IF AUTOMATION terminology tends to confuse you, and you are not sure just what analog and digital computers, A/D converters, transducers and the like are, or what they do, then the January issue of POWER ENGINEERING is for you.

Starting with three basic definitive articles that might well be termed a computer primer, the issue will then explain in detail all of the automation concepts from elementary scanning and logging through "sophisticated" data-logging and station analysis to the ultimate in push-button control.

Twelve of the nation's foremost authorities on the subject of computer control will examine every facet of this fascinating subject for you, all in the January issue.

ONE MAJOR PROBLEM plaguing engineers concerned with the automatic coal-fired plant is a method of analyzing coal and measuring fuel input to a boiler on a continuing basis within accuracy limits demanded by computer control. An instrument to perform this task adequately is available from Radiation Counter Laboratories in Skokie, Ill.

Originally developed as an effective means to permit cattle buyers to detect beef cattle who have been given an overdose of water prior to weighing, the same instrumentation is capable of instantaneously determining carbon, moisture and ash content of coal on a rapidly-moving conveyor belt, and of weighing that coal to an accuracy of one per cent. Unfortunately, such a system in today's market would cost upwards of $100,000.

CHANGES: Crane Co of Chicago has acquired by purchase all properties and assets of the Chapman Valve Mfg Co of Indian Orchard, Mass.

Dow Chemical Co has formed a new division to handle industrial chemical services. Known as the Industrial Service Division, it will take over solvent cleaning functions performed by the company's Dowell division, and will also provide services and products for municipal and industrial waste and water treatment. Headquarters will be in Cleveland, Ohio.

Bruner Corp, manufacturer of water-treating equipment, with plants in Milwaukee and Los Angeles, has become a wholly-owned subsidiary of Hagan Chemicals & Controls, Inc.

Prospect of a merger is in the offing for Joy Mfg Co and Western Precipitation Corp. Directors of the two companies are reported to have reached substantial agreement on a plan by which the net assets of Western will be transferred to Joy in exchange for Joy common stock.

Skinner Engine Co of Erie, Penna, has purchased the Power Equipment and Process Machinery Divisions of the Troy Engine and Machine Co of Troy, Pa. Products acquired include Troy engines, Troy-Engberg engines, American Blower engines, Whitin engines, Erie Ball engines, and processing equipment. Skinner Engine Co will be furnished all engineering data, patterns, jigs, and fixtures for the production of Troy engines, as well as repair parts for existing engines. In addition, Skinner Engine Co will also receive all research, development, experimental and engineering specifications, and will be appointed exclusive licensee for Troy differential-pressure power units (expander engines).

HONORS: To Ben Moreel, a director of Jones and Laughlin Steel Corp, Honorary Membership in ASME. Thomas B. Drew, professor of chemical engineering at Columbia University, has also been given this distinction.

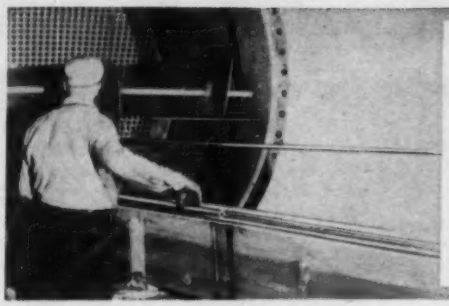
Westinghouse Electric Corp will be the first recipient of the Mamie Doud Eisenhower Award for contribution to nuclear propulsion, which has been set up by the New York Shipbuilding Corp to commemorate the launching of the *N. S. Savannah*, the world's first nuclear merchant ship. The medal is to be presented annually.

To Dr. Homer Hiram Lowry, of Wilmerding, Pa., the Percy Nicholls Award, presented jointly by AIMMPE and ASME "in recognition of outstanding achievement in the field of solid fuels."

To John T. Stiefel, manager of the surface ship project for Westinghouse at Bettis atomic power laboratory, the company's Order of Merit.

To Harry A. Kuljian, president of The Kuljian Corp, and Harvey F. McPhail, hydroelectric division manager of the same firm, appointment as non-paid consultants to the team from the Senate Committee on Interior and Insular Affairs. The group will visit Russia to view Soviet hydroelectric dams and other power facilities.

$9,275,000 GRANT has been given by the Ford Foundation to MIT for making extensive advances in engineering education. Seven major professorships in frontier areas of engineering are to be endowed. Wholly new curricula will be introduced.



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by A. W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

OPERATING FACTORS THAT AFFECT CONDENSER TUBE LIFE

Answers to some of the questions sent in following a previous clinic on this subject

Q. How effective is chlorination as a preventive maintenance procedure in cleaning tubes fouled by polluted water?

A. The chlorination of polluted sea water has been found to be effective in removing or preventing the formation of slimes on the walls of tubes. Better cleanliness was indicated by higher vacuum obtained on the steam side of the condenser. Tubes kept clean by chlorination have been reported to be less subject to pitting. It should be interjected here that tubes carrying polluted sea water containing sulfides from decomposition of organic matter seldom undergo inlet end corrosion, but the remainder of the length of the tubes often becomes pitted. Clean sea water, if entering the tube turbulently, will often cause corrosion at the inlet end, and usually the remainder of the length of the tube is coated with a good protective film of corrosion products.

The statement that chlorination may break down sulfide films on the walls of tubes is based on the fact that chlorine is an oxidizing agent and would oxidize sulfides; however, it is realized that the usual chlorine treatment would probably not remove thick long-standing sulfide scales.

Q. How often should tubes be cleaned and what are some of the methods used?

A. The required frequency of tube cleaning depends, of course, on how rapidly the tubes become fouled. In some power plants, tubes are cleaned once a week; at other stations, cleaning is required only at intervals of several months. Often the decision to clean tubes is determined by the drop in vacuum on the steam side.

In regard to methods for removing accumulations from condenser tubes, some station operators shoot rubber plugs through the tubes; others use bristle brushes, either of animal hair or nylon. The use of brushes is reported by some to do a better job of cleaning than the use of plugs.

An interesting method for continuously cleaning condenser tubes has been developed in Europe. A large number of sponge rubber balls, slightly larger in diameter than the inner diameter of the tubes and having about the same specific gravity as sea water, is fed continuously into the inlet water box. The cooling water forces the balls through the tubes, and deposits on the tube walls are swept away. The balls are collected by a cone in the outlet water box. They leave the water box through a tube connected to the end of the cone and are recirculated into the inlet water box. By the law of probability, each tube will eventually receive a ball. The system is not applicable to tubes that have been in service and have become rough and pitted.

Some stations periodically remove deposits from tubes by recirculating a dilute, inhibited hydrochloric acid solution through the condenser.

Q. How important are temperature and velocity as factors in the service life of condenser tubes?

A. Corrosion of condenser tubes is usually more rapid in summer than in the winter, but pollution due to bacterial action in the summer may be a more important factor than temperature itself. Instances have been observed where failures in a set of tubes occurred only in the warm-water months and none in the cold-water months, over a period of several years.

Mention was made in the clinic to the effect that high temperature of water causes pitting, due to the formation of gas bubbles on the tube wall. This type of pitting occurs most frequently, but not often, in oil refinery condensers where temperatures on the vapor side may be as high as 350F and water velocities relatively low. In a power plant condenser, temperatures on the vapor side ordinarily do not exceed 100F and temperature rise in the cooling water from the inlet to the outlet end is usually limited to 10F.

TECHNICAL ASSISTANCE. Our Metallurgical Department is regularly helping manufacturers, electric power companies, marine operators, petroleum and chemical companies to select the correct tube alloy for many types of condensers and heat exchangers. This service is available to you without obligation. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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WHAT THEY TELL US

Pumped storage basin at Geesthacht station in W. Germany, drained for inspection. Dark area is mud deposit

▶ **MORE ON SEALING** for pumped storage basins has reached us from Rudolf Meister in Hamburg, Germany. Meister described a pumped storage project in the May, 1959 issue of POWER ENGINEERING, page 80. Basin of that installation was drained in May, 1959, after a year and a half of use, to determine the state of the basin. Here's what Meister reports:

> After draining, about 20,000 m of mud remained in one part of the basin. At the moment, the removal of this mud is troubling us. However, it has been possible to inspect the total sealing surface by shifting the mud aside. It can be stated that the sealing of the storage basin was satisfactory to the greatest extent. Only defect was the formation of blowholes in the 2-mm mastic layer up to a diameter of 5 cm. These blowholes were removed when their diameter exceeded 3 cm, and were newly filled with a bituminous compound. The asphalt concrete below the blowholes was found to be satisfactory.

▶ **TEAMING UP** of boiler manufacturers with the insurance companies in a coöperative volunteer program of education for boiler operators is being advocated by Patrick D. Goggin, chief engineer of Boiler Engineering & Supply Co of Phoenixville, Pa. Goggin says:

> In dramatic statistics assembled by the Hartford Steam Boiler Inspection and Insurance Co, the preponderant cause of boiler failures has been traced to human failure. This represents a fertile area for intensive educational promotion.
>
> By actual tabulation, 85.2 per cent of 1715 steel firetube boiler failures were traced to the neglect, carelessness, indifference, or ignorance on the part of the boiler operator. Over half of the failures were reported as failure to test and maintain control devices.
>
> Growing popularity of the automatic package firetube boiler in institutional and commercial applications, and even in smaller industrial applications, where trained boiler operators are not normally avilable, probably helps to explain the large proportion of diagnoses as failure to maintain and test the controls.
>
> Most important part of a boiler startup is that phase concerned with the proper indoctrination and instruction of the man responsible for the care and maintenance of the boiler. This problem of operator instruction cannot be treated lightly without the severe risk of incurring later customer dissatisfaction. Changes and turnover of boiler operating personnel make the problem doubly frustrating. We have been constantly and continuously working toward the better education of the boiler operator.

Aruba's new stamp saluting water plant

▶ **NEW STAMP** issued in October by the Island Territory of Aruba, Netherlands West Indies, honors an engineering achievement. The stamp carries a photograph of a line of huge cast iron evaporators in the government-owned sea water distillation plant, recently designed and built by Singmaster & Breyer, Inc, New York engineers. In calling this to our attention, Ed Dembitz of the company reminds us that:

> First engineering project depicted on a U. S. postage stamp was the Mississippi River Bridge at St. Louis in 1898. More recent U. S. commemorative stamps have shown the Mackinac Straits Bridge (1958); Grand Coulee Dam (1952); and the Atlantic Cable (1958 centenary). Two bridges — the George Washington and a stylized covered bridge — were on a single stamp issued in 1952 to mark the 100th anniversary of ASCE.
>
> The new Aruba stamp of the water plant is more in the nature of a triumphal salute. Expansion of that arid Caribbean island's economy, almost completely dependent upon an oil refinery, had been limited by a lack of ample water and electricity. The new plant solves the shortage problems. It is the world's largest single installation for converting sea water to fresh water (2,700,000 gpd) and the first conversion plant to produce marketable surplus electricity (12,500 kw).

▶ **MOST UNUSUAL** power engineer apprentice we've run across lately is Sister Michael of St. James Hospital in Butte, Montana. This hospital is run by the Sisters of Charity of Leavenworth, and Sister Michael is a registered nurse in charge of the operating room; but the boiler room is also a center for her interest. We asked her to tell us something about this. She writes:

> I am only a fledgling in your profession, but in time I hope to be a qualified engineer. For many years, I have been interested in power plant engineering, but it has only been in the last couple of years that I have had the opportunity of spending some time almost every day in the boiler plant.
>
> We have two Kewanee high-pressure firetube boilers. We also have a 75-kv heavy-duty reserve generator which carries the hospital load, in case of city power shutdown. We also maintain our own laundry. Three engineers operate our boiler plant and also have the maintenance of the hospital.
>
> We do have a sister who has a full-time job in the boiler plant at our motherhouse in Xavier, Kansas. Since I have had no special training and am trying to acquire some of the knowledge on my own, I am always looking for information and other learning sources, and one of these sources is your magazine, POWER ENGINEERING, which I read from cover to cover.

Sister Michael in the boiler room of St. James Hospital in Butte, Montana

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

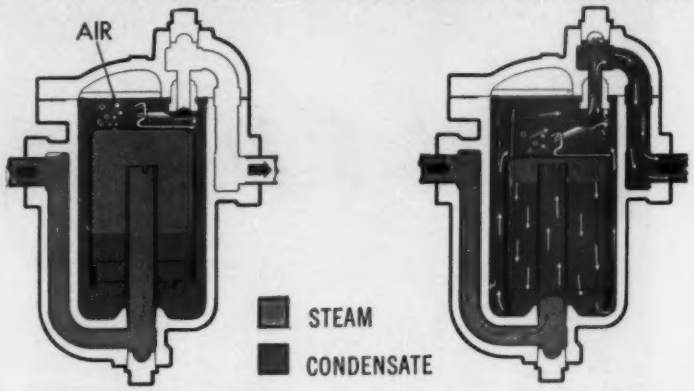
5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

Armstrong Machine Works
8103 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

HERE'S THE STEAM TRAP DESIGN
THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



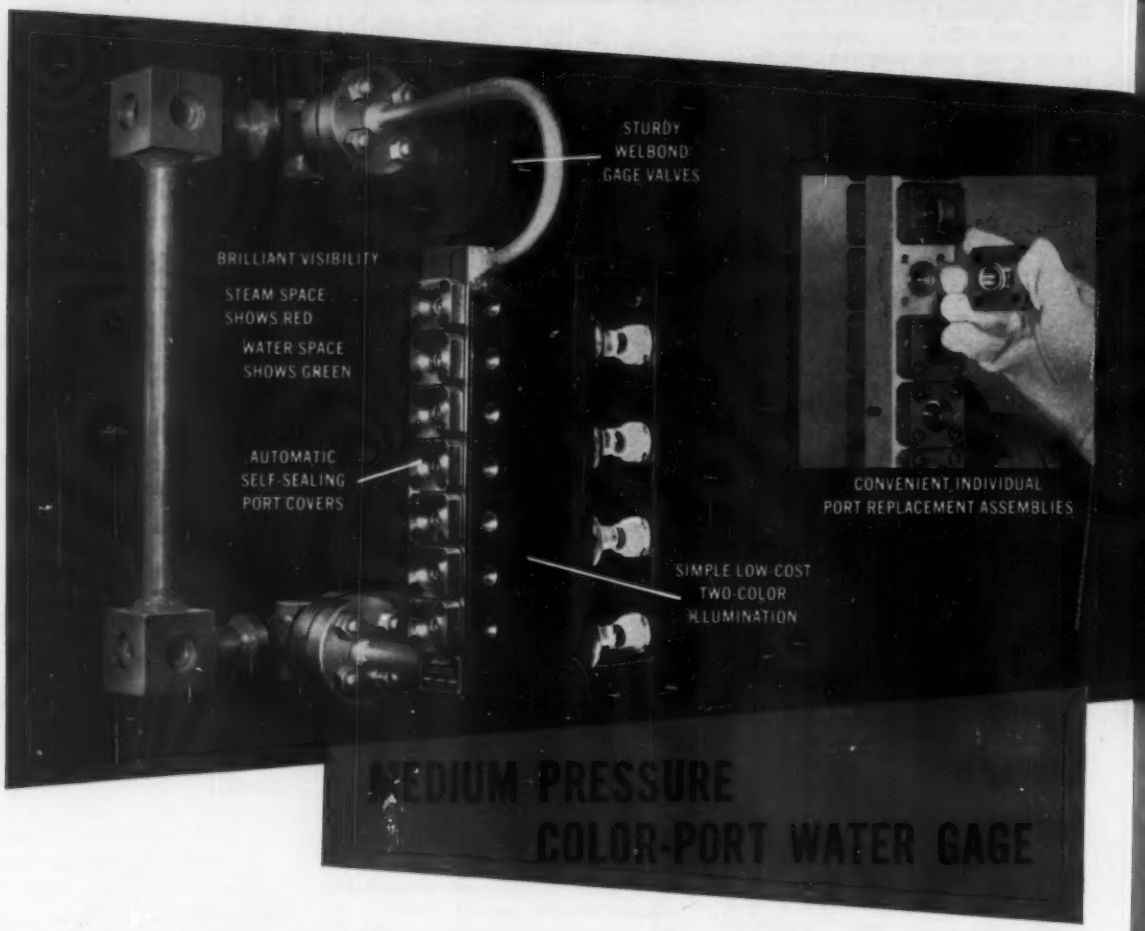
Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

"See our catalog in Sweets Plant Engineering File"

For more data circle 505 on Post Card

NEW YARWAY TRIM FOR MEDIU
FEATURES AND DEPENDABILIT



These advantages, so successful in high pressure* Yarway Color-Port Water Level Gages, are now incorporated in the new Yarway Color-Port for boilers operating up to 1050 psi.

- Bright red and green readings. Full gage shows all green; empty gage, all red.
- Low maintenance. Individual port assemblies can be replaced in a matter of minutes—with the gage in place. Efficient illuminator spotlights reduce lighting costs.
- Automatic self-sealing ports. Exclusive spring loading of port covers maintains proper pressure on glasses and gaskets at all times.
- Sturdy Yarway Welbond Gage Valves for positive, dependable shut-off service.

For replacement on existing medium pressure boilers or specifying on new units, make sure your next gages are YARWAY COLOR-PORT. Visibility ranges of 13", 15½" and 18" available.

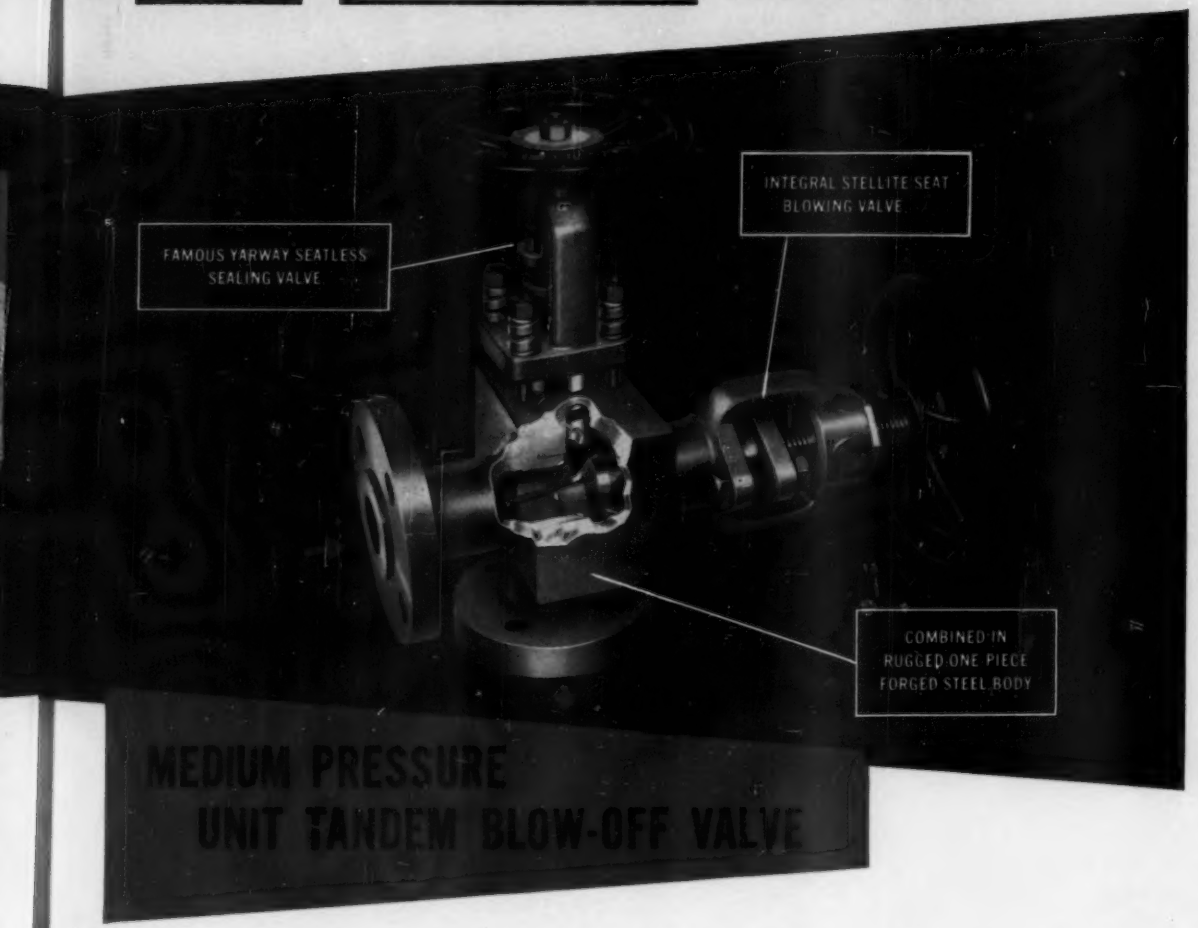
Write for new Bulletin WG-1815.

*up to 3000 psi

YARWAY

A MARK OF QUALIT

UI RESSURE BOILERS HAS UNIQUE
T) F HIGH PRESSURE DESIGN


FAMOUS YARWAY SEATLESS SEALING VALVE
INTEGRAL STELLITE SEAT BLOWING VALVE
COMBINED IN RUGGED ONE PIECE FORGED STEEL BODY
MEDIUM PRESSURE
UNIT TANDEM BLOW-OFF VALVE

The established success of the high pressure Yarway Unit Tandem Valve is directly responsible for this new medium pressure Yarway Valve. It brings premium quality Yarway dependability to medium pressure boilers (up to 665 psi)—*at a competitive price.*

Important Yarway features like nitralloy plunger in the sealing valve, integral stellite seat and disc in the blowing valve, streamlined design, rugged forged steel body—make this your best blow-off valve buy.

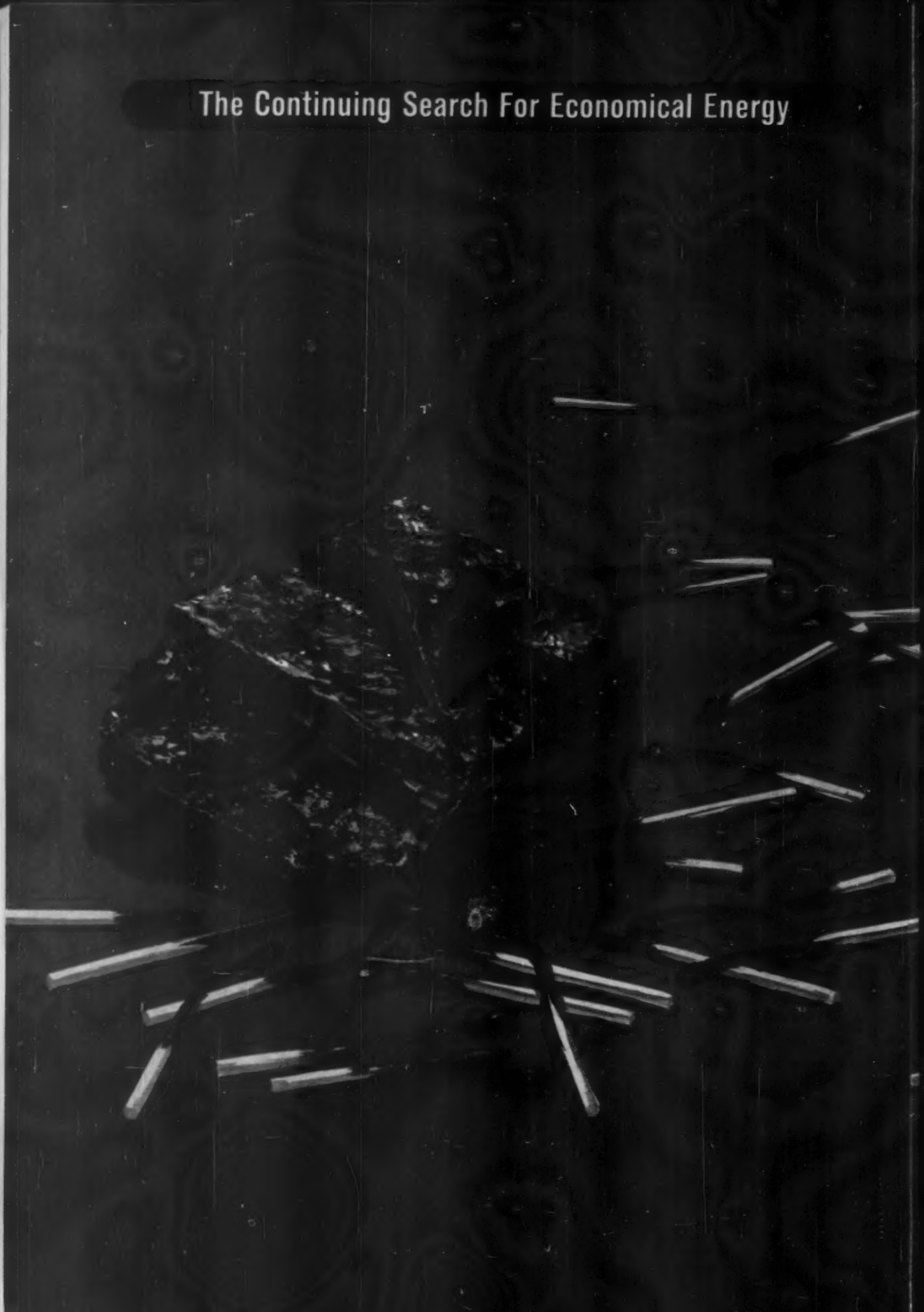
Install this new Yarway Medium Pressure Unit Tandem and you'll know why *over 80% of all high pressure plants are Yarway Blow-off Valves.*

Write for Bulletin B-435, Supplement A.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

TN STEAM ENGINEERING

The Continuing Search For Economical Energy



Now—Btu's from coal that "Can't Be Burned"

Utilities who thought it couldn't be done, are now burning low-cost, low-grade, high-ash coal—helping to keep kilowatts America's biggest bargain.

The reason? B&W fuel research that led to the design of the Cyclone Furnace. Fact is, the B&W Cyclone Furnace was *designed* to burn the really "tough" coals—and squeeze the maximum Btu's from every pound.

Behind the Cyclone's success are more than 33,000 B&W fuel analyses. With this tremendous background and experience, B&W can build fuel burning equipment around the fuel *you'll* burn. It means you can utilize available low-cost fuels you could never use before.

Important to you, too, is B&W's complete objectivity in making recommendations. For B&W manufactures all types of fuel burning equipment—for every application. Why not discuss your special requirements with us now. Write to The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

G909-C5

THOMAS JEFFERSON BUILDING

Electrical services are fed from two 4,000 amp. main distribution boards. Each of the main switch boards is fed by 8-500 MCM conductors per phase.

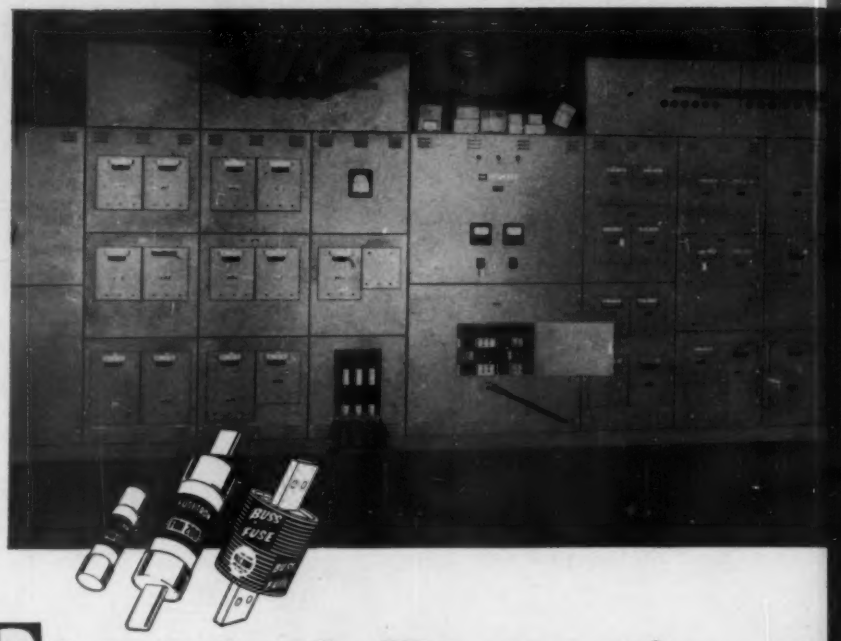
Switch Board #1

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 12-600 amp., 30-400 amp., 3-200 amp. FUSETRON Fuses.

Switch Board #2

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 6-600 amp., 33-400 amp., 39-200 amp. FUSETRON Fuses.

All distribution panels protected by FUSETRON dual-element fuses.



Electrical Protection goes MODERN *with* BUSS Fuses

in St. Louis' Newest Multi-Storied Office Building . . .

The Thomas Jefferson Building is another outstanding example of BUSS Hi-Cap and FUSETRON dual-element fuses meeting the requirements for a modern protective device for use in modern electrical systems.

Today's electrical networks, with their tremendous capacities, have emphasized the need for a superior protective device that can be relied on to safely and dependably handle faults of great magnitude.

BUSS Hi-Cap and FUSETRON fuses, because of their high interrupting capacity and life-time dependability have become the natural choice in both new installations and when electrical systems are being modernized.

WHY HIGH-INTERRUPTING CAPACITY AND DEPENDABILITY ARE ESSENTIAL FOR A MODERN PROTECTIVE DEVICE...

CAPACITY

The magnitude of fault current is only limited by the capacity of the transformers or networks. These capacities have been increasing yearly — and most likely will continue to increase.

A modern protective device, therefore, must be capable of interrupting faults of 75,000 to 150,000 ampere which are available today — and be adequately safe to allow for future system growth.

BUSS Hi-Cap and FUSETRON dual-element fuses meet this requirement. The interrupting rating of BUSS Hi-Cap fuses is 200,000 rms symmetrical — and for FUSETRON fuses it is 100,000 rms symmetrical.

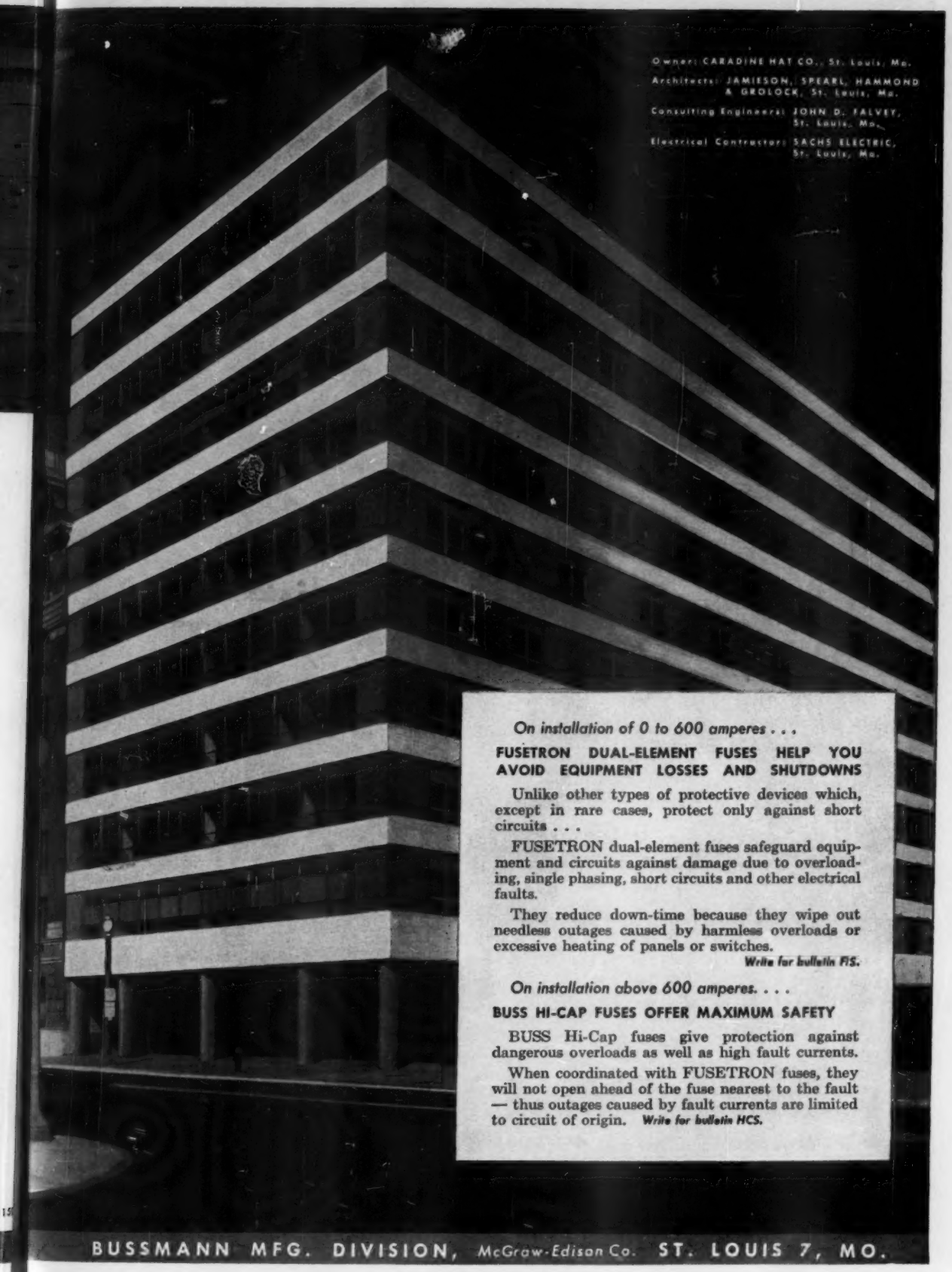
LIFE-TIME DEPENDABILITY

The *Modern* protective device should remain just as safe and accurate through the years as it is on the day installed. Otherwise, how can you be sure it will interrupt these high fault currents should trouble occur 10, 15 or 20 years from now.

This requirement too, is met by BUSS Hi-Cap and FUSETRON fuses — They remain safe and accurate and require no periodic inspection or recalibration, as they have no hinges, pivots, latches or contacts to stick or get out of order.

115

ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION


Owner: CARADINE HAT CO., St. Louis, Mo.
Architects: JAMIESON, SPEARL, HAMMOND & GROLOCK, St. Louis, Mo.
Consulting Engineers: JOHN D. FALVEY, St. Louis, Mo.
Electrical Contractor: SACHS ELECTRIC, St. Louis, Mo.

On installation of 0 to 600 amperes . . .

FUSETRON DUAL-ELEMENT FUSES HELP YOU AVOID EQUIPMENT LOSSES AND SHUTDOWNS

Unlike other types of protective devices which, except in rare cases, protect only against short circuits . . .

FUSETRON dual-element fuses safeguard equipment and circuits against damage due to overloading, single phasing, short circuits and other electrical faults.

They reduce down-time because they wipe out needless outages caused by harmless overloads or excessive heating of panels or switches.

Write for bulletin FIS.

On installation above 600 amperes. . . .

BUSS HI-CAP FUSES OFFER MAXIMUM SAFETY

BUSS Hi-Cap fuses give protection against dangerous overloads as well as high fault currents.

When coordinated with FUSETRON fuses, they will not open ahead of the fuse nearest to the fault — thus outages caused by fault currents are limited to circuit of origin. ***Write for bulletin HCS.***

BUSSMANN MFG. DIVISION, *McGraw-Edison Co.* **ST. LOUIS 7, MO.**

For more data circle 508 on Post Card

NEW EDWARD IMPACTOGEAR

What's New from Edward Valves

New Products . . . Solutions to Problems . . . Information on Steel Valves from Edward, Long-Time Pioneer in the Field!

How Impactogear* operates high-pressure valves

You no longer need a crew of men to open or close big, high-pressure valves. New Edward Rockwell-built Impactogear makes big-valve operation a quick and easy job.

FAST AND EASY "RUNDOWN"

Your operator simply applies portable air or electric wrench to pinion shaft-end of Impactogear. When power is applied, pinion turns ring gear, which turns handwheel and moves the stem to "closed" position. Impactor* handwheel then gives final tight shut-off with unique "hammer-blow" action. (Tests show it delivers 12 times the closing force of ordinary handwheels—with less effort!) Impactogear works quickly, can operate a 2500-lb 10" valve (for example) in only 2½ minutes. And Impactogear can be fitted to any 8" or larger Edward valve of 900-lb (or higher) pressure class.

IMPACTOGEAR WITH AIR WRENCH

Impactogear utilizes standard portable air or electric wrenches generally available throughout industry. Example below shows how two typical air wrench ratings can be applied:

Wrench Type No. 1—Stall torque 170 ft-lbs: Free speed 225 rpm; Weight 12 lbs

For 12" and 14" 2500 lb. valves, operating pressures to 3500 psi

For 10" 2500 lb valves, all allowable operating pressures

For 10", 12" and 14" 1500 lb valves, all allowable operating pressures

For 12" and 14" 900 lb valves, all allowable operating pressures

Wrench Type No. 2—Stall torque 200 ft-lbs: Free speed 300 rpm; Weight 38 lbs

For 12" and 14" 2500 lb valves, operating pressures 3500 psi to 4500 psi

IMPACTOGEAR WITH ELECTRIC WRENCH

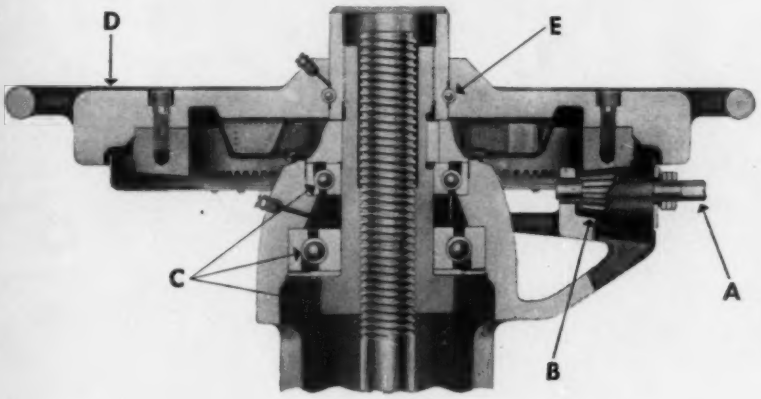
Portable electric wrenches are equally practical. Example below shows a typical electric wrench rating as applied to Impactogear:

Wrench Type No. 1—Stall torque 176 ft-lbs: Free speed 225 rpm; Weight 44 lbs

For 10" 2500 lb valves, all allowable operating pressures

For 10" and 12" 1500 lb valves, all allowable operating pressures

For 12" and 14" 900 lb valves, all allowable operating pressures



Details of new Impactogear and Impactor Handwheel:

A—Hex head of pinion gear shaft. Power wrench is applied here. B—12-to-1 bevel gear ratio is typical for median size handwheel. C—Exclusive EValthrust yoke bushing combines radial and thrust bearings for easy operation and long life. D—New Impactor handwheel concentrates mass near outer circumference for maximum impacting efficiency. E—New extra bearing increases operating efficiency.

SLASH COST OF VALVE OPERATION

Individually installed operating motors are a big investment. They can add as much as 100% to the basic valve cost. *But now you can save that money by standardizing on Impactogear*—radically simple, thoroughly dependable mechanism utilizing *existing* compressed air or electric facilities. Your Edward Representative will be glad to provide full details and help you determine how Impactogear can work to your best advantage. Contact him—or write *Edward Valves, Inc., 1202 W. 145th Street, East Chicago, Indiana.* (Subsidiary of Rockwell Manufacturing Company). Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W., Montreal 1, Quebec.

LIGHTWEIGHT PORTABLE WRENCH can operate as many Impactogear-equipped valves as desired. Or, each valve can be fitted with its own wrench. Either way, you get lower operating costs. Final closing is effected by handwheel lugs (A) striking hammer blows against cross arm keyed to yoke bushing (B). Half of gear cover was removed for illustration purposes.

*T.M. Reg. U.S. Pat. Off.

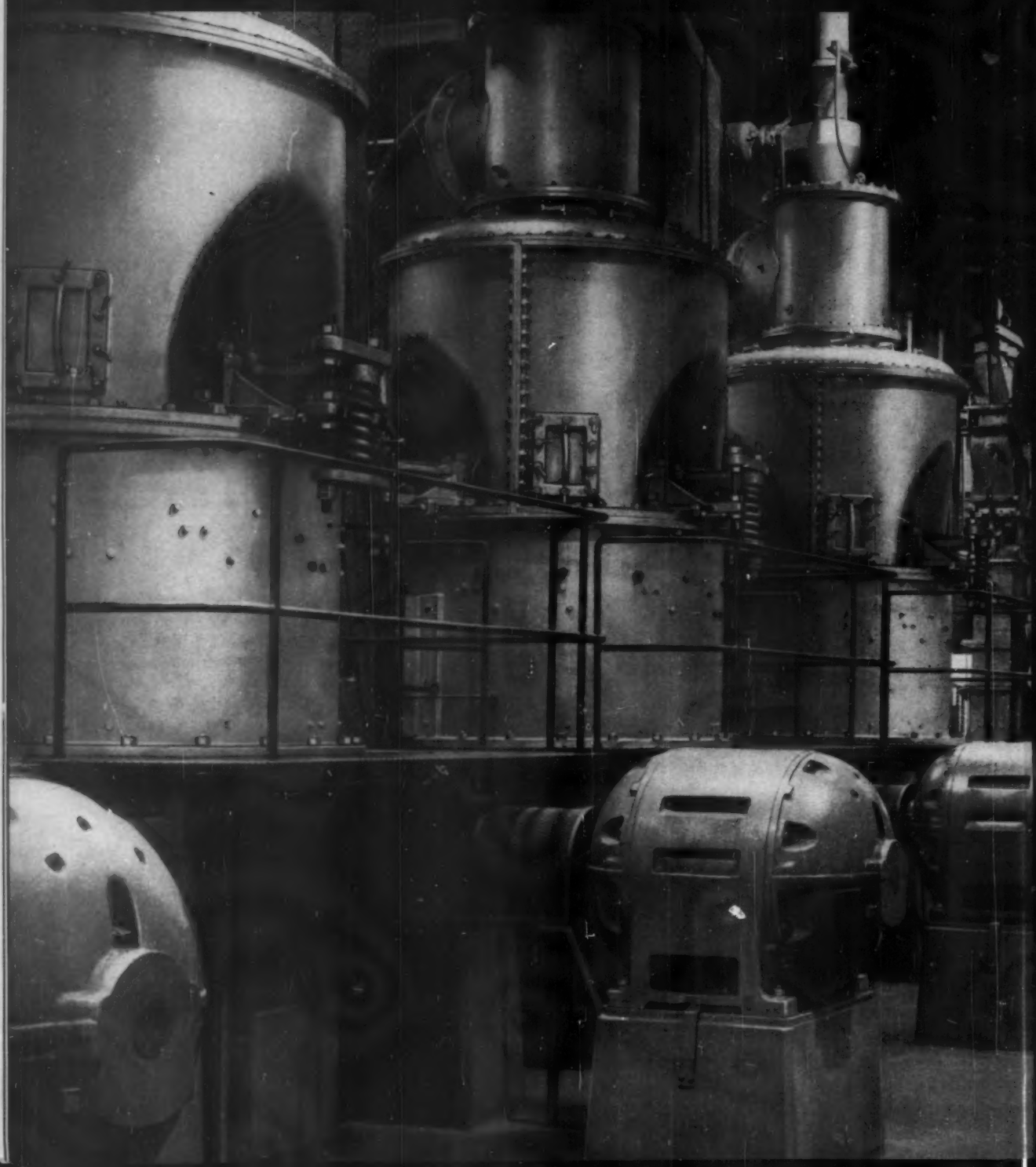
EDWARD STEEL VALVES
another fine product by
ROCKWELL

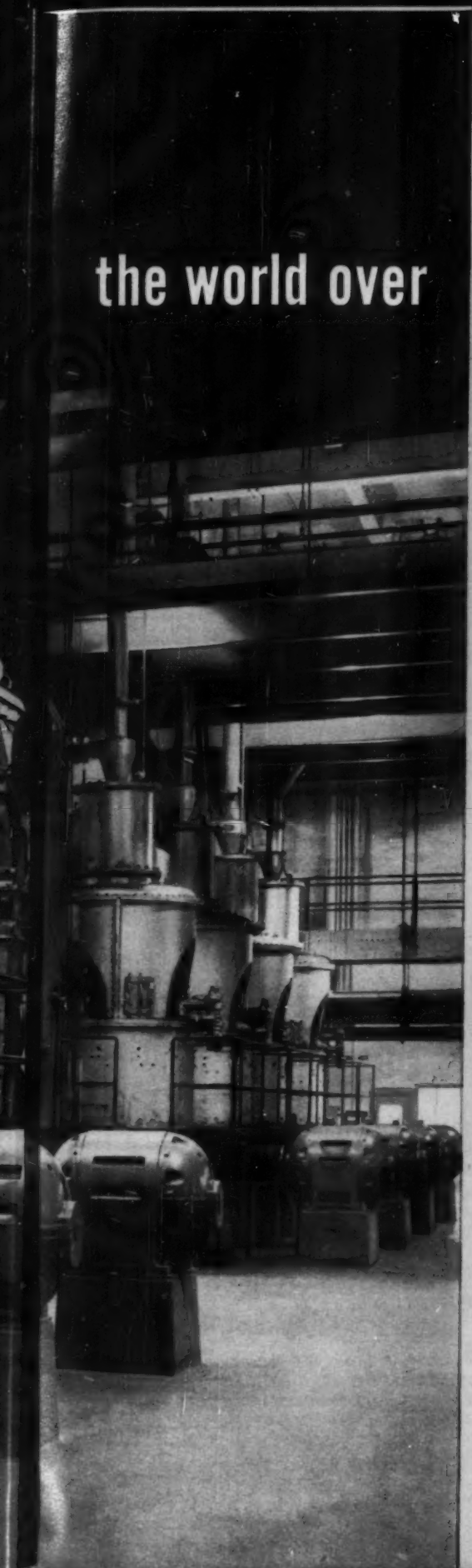
Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.

For more data circle 509 on Post Card

BOWL MILLS LIKE THESE

prepare the daily BTU diets of boilers





C-E RAYMOND BOWL MILLS pulverize lignite in Mallorca, Spain... coke in Buenos Aires... semi-bituminous coal in Limburg, Holland ... bituminous in Tanagawa, Japan... furfural residue in Tennessee ... and petroleum coke in Indiana. But their biggest field of application, by far, is pulverizing various kinds of coal in hundreds of American utility plants from coast to coast. In all, they feed the boilers of the world with some 37,000 tons of fuel each hour — boilers with an aggregate steam generating capacity of about...

400,000,000 lb. per hr.

There are eight big reasons why the C-E Raymond Bowl Mill is so popular — reasons that are important to you if pulverized fuel is part of your plant picture. They are...

1. **Handles High Moisture Fuels** — High moisture fuels are handled without difficulty because the Bowl Mill premixes raw coal with the dried product in an atmosphere up to 700 F air. Even lignite with 50% moisture is thoroughly dried.
2. **Low Power Consumption** — Rapid flow of material through the mill, prompt removal of fine coal, fast drying and relatively low weight of grinding elements all combine to assure minimum power consumption.
3. **Continuous Service** — The Bowl Mill provides continuous service for long periods because there is no metal-to-metal contact between rings and rolls and wear is minimized. Logs showing 20,000 hours of continuous operation are not uncommon.
4. **Low Maintenance** — Maintenance is required less frequently because the Bowl Mill stays in service for longer periods. When replacement of parts is necessary, outage time is minimized because of the ease with which the machine can be taken apart and reassembled.
5. **Fineness Control** — Changes in fineness control can be made while the Bowl Mill is operating because the necessary adjustments are made from the outside. The mill need not be stopped.
6. **Automatic Grinding Adjustment** — Grinding pressure is automatically adjusted to suit fuel characteristics because the Bowl Mill uses spring-loaded journals which instantaneously compensate for variations in coal grindability.
7. **Infrequent Lubrication** — Only infrequent lubrication is required with the Bowl Mill. When required, it can be done from outside the mill without taking it out of service.
8. **Vibrationless-Quiet** — The Bowl Mill's grinding rollers make no metal-to-metal contact with the grinding ring, assuring quiet, vibrationless operation.

Whether you are considering pulverizers for your present plant expansion program or for future requirements, we suggest you investigate the advantages of the Bowl Mill as outlined above and described more fully in our Catalog PC-8.

COMBUSTION ENGINEERING

C-E

C-229

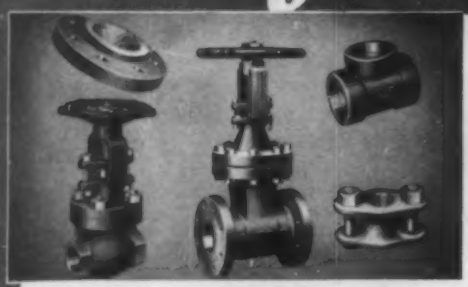
200 Madison Avenue, New York 16, N. Y.

Combustion Engineering Building

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

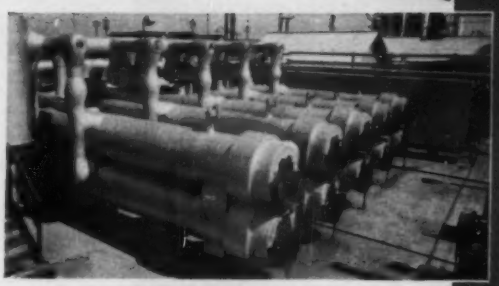
Vogt PRODUCTS

Designed for today's Tough service demands



FORGED STEEL VALVES & FITTINGS FOR TOUGHNESS AND TROUBLE-FREE SERVICE

Forged from carbon and alloy steels, Vogt valves, fittings, flanges and unions are built to safely handle liquids and gases at high pressures and temperatures in the modern petroleum refinery and petro-chemical plants. The complete line includes flanged, screwed and socket weld end globe, gate and check valves—ells, tees and crosses—couplings—bushings—plugs—unions—flanges and flange unions—and weld caps.



PROCESS EQUIPMENT FOR EVERY SERVICE

Vogt constructs process equipment in wide variety to all Codes. Stills and towers, oil chillers, crystallizers, heat exchangers, molding machines, etc., serve in the manufacture of oils, greases, 100 octane gasoline, synthetic rubber, chemicals and related products around the world.

MORE REFRIGERATION TONNAGE AT LESS COST

More than 70 years of engineering and manufacturing experience is incorporated in Vogt refrigerating and ice making equipment. Compression Systems and Tube-Ice Machines in a wide range of capacities serve industrial and processing plants and institutions here and abroad.

HIGH EFFICIENCY STEAM GENERATORS

Vogt steam generators are designed to give maximum rating in a minimum of space, with high efficiency and low maintenance expense. Bent tube and straight tube designs are available for solid, liquid or gaseous fuels to meet every power, process or heating requirement.

SPECIAL MATERIALS COMBAT CORROSION AND PRODUCT CONTAMINATION

Our modern shops produce a wide variety of equipment from special metals and alloys to fight corrosion and product discoloration or contamination. Fabrication procedures insure that corrosion resistant properties of welds will match that of the materials used to construct the equipment.

HENRY VOGT MACHINE CO., LOUISVILLE, KY.

SALES OFFICES:
New York, Chicago, Cleveland, Dallas, Camden, N. J.,
St. Louis, Charleston, W. Va., Cincinnati

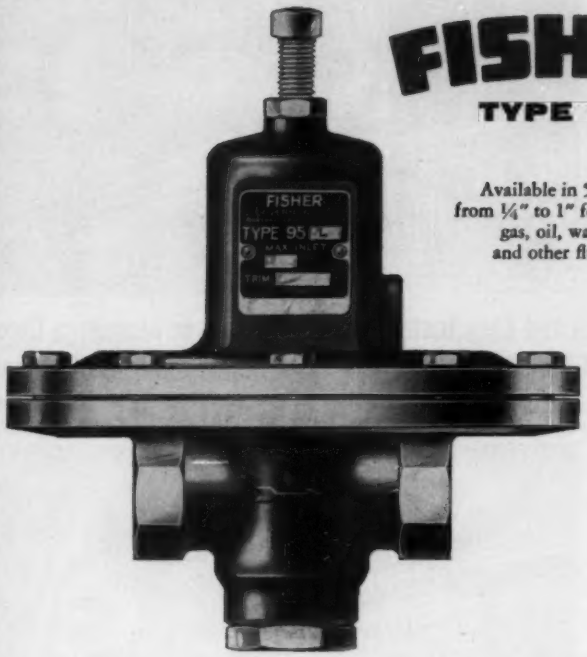
PRODUCTS FOR REFINERIES, CHEMICAL PLANTS, POWER PLANTS AND PROCESS INDUSTRIES
Write for literature, Dept. 24A-GPE

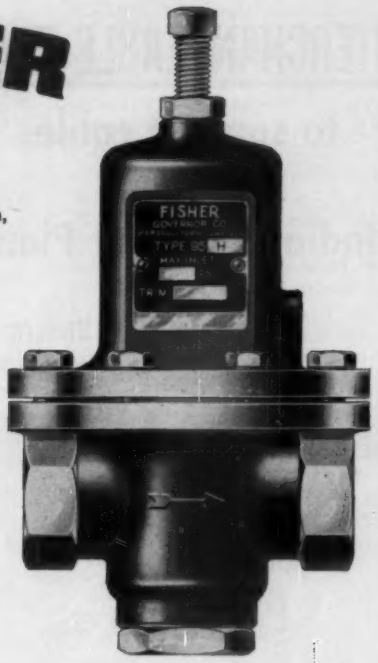
Small Regulator Does Many Jobs!

FISHER

TYPE 95

Available in 5 sizes from ¼" to 1" for steam, gas, oil, water and other fluids





TYPE 95L with iron body and composition disc or stainless steel trim. For outlet pressures from 2 to 30 psi.

TYPE 95H available in cast steel or iron bodies for outlet pressures up to 150 psi.

Small Size, Large Capacity, Ideal for Limited Space Jobs

As usual, Fisher engineers have packed this small but mighty regulator with a number of outstanding features.

A. **Installation is quick and easy, no external lines, piping or connections.**

B. **Extremely stable because diaphragm is located in isolated chamber out of the flow stream. No fluid velocity impingement possible.**

C. **Positive two-point guiding for stem assures smooth action and perfect alignment.**

D. **Higher capacity results from utilizing downstream pressure through a small registration tube located to produce a velocity boost action. Holds more constant pressure over a wide flow range.**

Another outstanding feature is ready accessibility of all parts. Cleaning or inspection is quickly accomplished with simple tools and without removal from the line. Even the diaphragm may be replaced without disturbing the inner valve or orifice.

FOR COMPLETE DATA WRITE FOR BULLETIN C-95

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

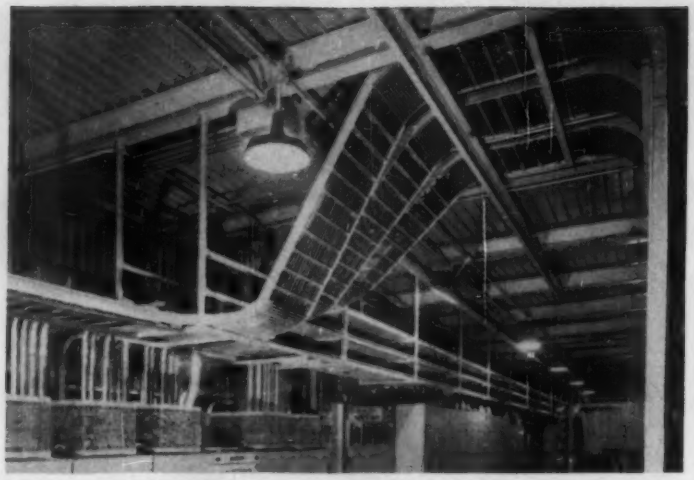
Marshalltown, Iowa / Woodstock, Canada / London, England

FISHER®

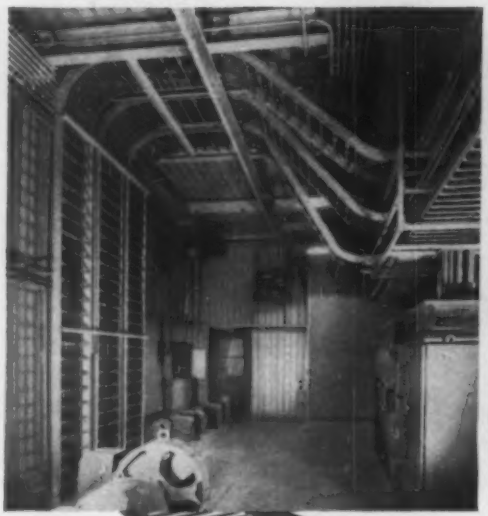
SINCE 1880

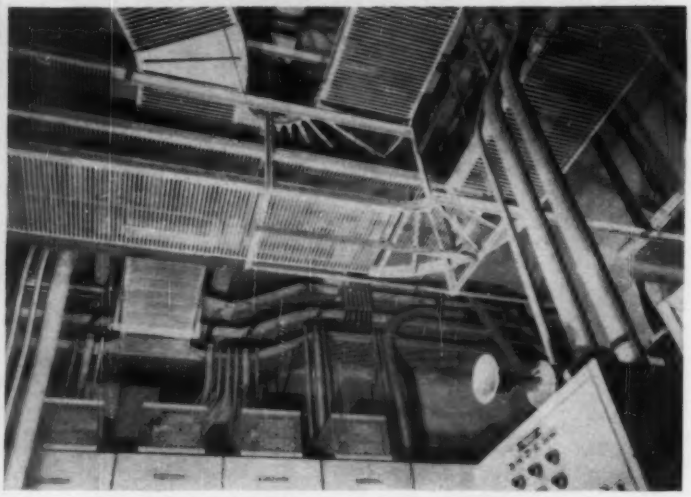
For more data circle 512 on Post Card

how INLAND STEEL uses GLOBE INTERCHANGEABLE TRAYS to support cables in their Indiana Harbor Plant



★ Engineered for Uniform Design and Easy Installation
★ Steel or Aluminum Construction
★ Complete Accessories for SPEEDIER Installation
★ Complete Interchangeability
★ No Sharp Edges to Damage Cables





Globetray Pat. Pending

LADDER TYPE

BASKET TYPE (One-piece construction)

Globe's two types of cable trays, one a ladder type and the other a basket type, to support cables, wiring and tubing have become increasingly popular because they can be used INTERCHANGEABLY at any given location depending on the type and weight of the cables to be suspended. The advantages of each type tray can be used to the fullest. Globetray, the ladder type, is intended for use where festooning is not a problem, while Cable-Strut, the basket type, is used for the support of communication wire, instrument tubing and control cables in automation applications.

These two cable trays have been thoroughly field tested in hundreds of large industrial installations, in new plant construction, in power plants and for power distribution in all types of manufacturing processes. Send for FREE catalog giving full information and installation techniques.

PRODUCTS DIVISION
THE GLOBE COMPANY Manufacturers since 1914
4022 S. Princeton Ave., Chicago 9, Ill.

Representatives in all principal cities . . . consult the yellow pages in your phone book under "Conduits" for the one nearest you.

For more data circle 513 on Post Card

Hall Industrial Water Report

VOLUME 7 DECEMBER 1959 NUMBER 6

How Will It Come Out?

Industrial water softeners of many types are daily turning out millions of gallons of treated boiler feedwater. Usually the softener effluents are of good quality, meeting chemical specifications and suitable for the intended use. But things can go wrong both mechanically and chemically, and close control is essential to make sure the water "will come out all right."

Hall Laboratories engineers are thoroughly familiar with water softening procedures and equipment. They can serve you not only in setting up, but also in maintaining the routine control necessary to make your equipment operate efficiently. And they can help you determine the cause of trouble when, for no obvious reason, effluent quality is poor.

Coagulant Aid Helps Softening

The hot lime soda—hot zeolite water softener at a western paper mill functioned satisfactorily until demand pushed flow rate up to and beyond the capacity of the unit. Then more sludge was carried out of the sedimentation tank in the lime soda-treated water than the filters could handle. Some went on to the hot zeolite softeners, seriously fouling the ion exchange material. Excessive backwashing was necessary.

Hall engineer L. Arnold considered how he might hasten settling of precipitated sludge in the sedimentation tank. He recommended the use of a Hagan coagulant aid because this represented the quickest and probably most effective move.

Results were impressive. Soon after the aid was added to the lime and soda ash chemical tank the settled water cleared up. The plant operators enthusiastically pointed out that there was less suspended material in the water going to the filters than there had been previously in the effluent coming out of them.

Hardening Condensate

An automobile parts manufacturing plant prepares boiler feedwater in a hot-process softener. There are two sections in the equipment, one for deaeration of condensate and one for heating and lime-soda softening of makeup. The softened water is filtered and combined with the deaerated condensate.

The operators watched water conditions carefully and operated without trouble for some time. Then one day they were puzzled by unprecedented difficulty in maintaining reserve phosphate in the boiler water. Wishing to solve the problem as quickly as possible they called Hall engineer D. W. Whiteside.

When Whiteside arrived at the plant the operators reported to him their observation that the normally clear boiler feedwater was turbid. The turbidity was quickly determined to be sludge from the softening section of the hot process unit. Further checking showed that the sludge was in the deaerated condensate while the treated, filtered makeup water was clear.

Now it was obvious that something was wrong inside the softener, permitting treated water from the softening section to get into the condensate section. Subsequent inspection revealed partial plugging of the downflow pipe through which treated water flowed from the primary softening zone to the settling chamber. Water level rose high enough in the primary softening zone to spill the treated water over the baffle separating this from the condensate section.

A good cleaning of the downflow pipe corrected the trouble. Routine cleaning during regularly scheduled shutdowns was established to avoid future difficulty.

Care of Ion Exchange Resins

Exchange resins are expensive. A running check on performance is important in setting up cleaning and replacement programs which assure maximum useful life and put replacement cost on a uniform annual basis thus avoiding sudden major replacement expenditures.

Plant operators should carefully watch the relationship between raw water composition and gallons of water treated between regenerations of cation exchangers. A noticeable drop in capacity can give early warning of the need for cleaning.

Gradual increase in pressure drop across a cation bed is an indication that the material is becoming dirty or is starting to break down. This information should be used in conjunction with service capacity data to check condition of the resin.

Crosslinkage checks are desirable about once per year for small cation units and twice per year for large units. If caught in time, breakdown can sometimes be retarded by treatment of the water with sodium sulfite or sulfur dioxide.

The condition of anion exchange material is best watched by observing the amount of dissolved solids removed per cubic foot of resin per cycle.

Rinse requirement is important too. Increase often means deterioration or fouling. The observations may be used alone or together to determine the need for cleaning or replacement.

Hall engineers can help you set up and maintain routine testing and regeneration programs as well as the longer term checks on performance. Furthermore, Hall Laboratories is well equipped and staffed to do special work on resin capacity, crosslinkage and experimental cleaning.

Water is your industry's most important raw material. Use it wisely.

Industrial Water Problems Require Special Handling

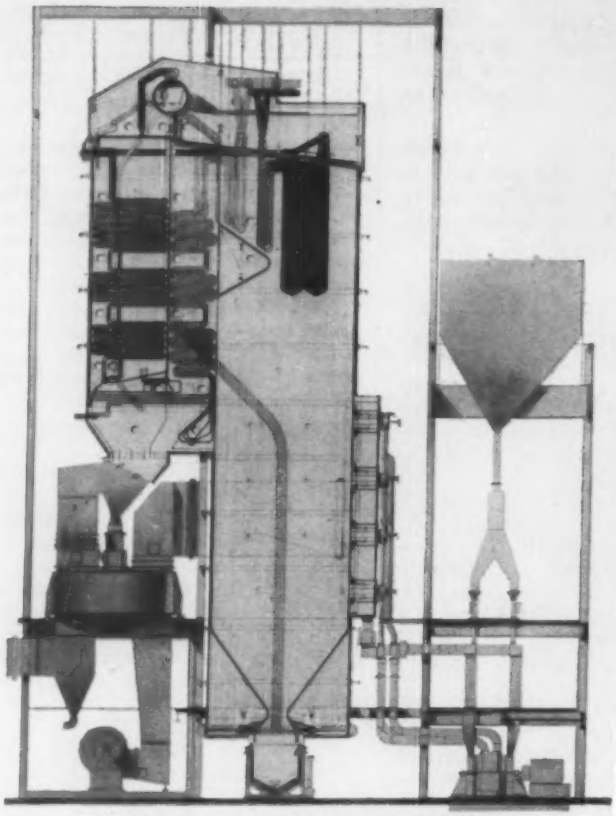
There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems, write, wire or call address below.

HALL LABORATORIES
DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

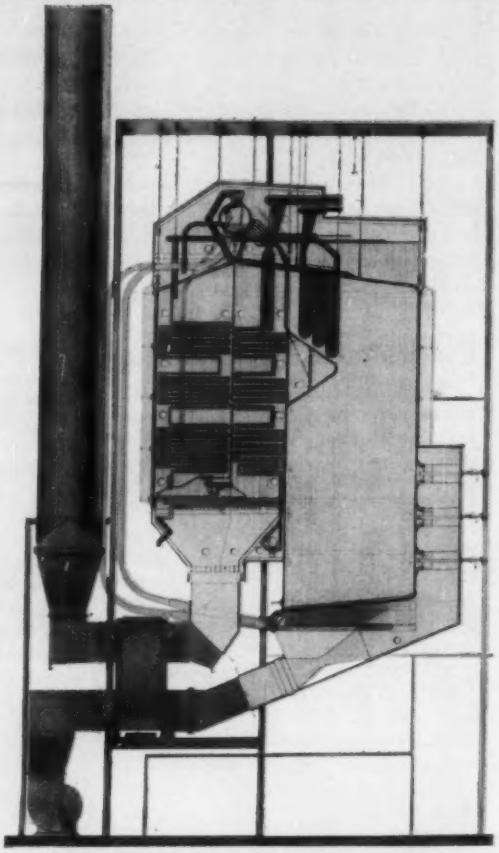
Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

For more data circle 514 on Post Card

Are You Planning To Burn COAL ? OIL or GAS ?



950,000 lbs./hr., 1950 psig, 1000/1000F;
Fired By Riley Pulverizers, Flare Type Burners



1,020,000 lbs./hr., 1925 psig, 1005/1005F;
Fired By Gas, Oil — Pressurized Furnace

Riley Custom Boiler Engineering, Know-How In Combustion Can Give You Top Performance Regardless Of The

Riley Boilers Equipped With Complete Riley Fuel Burning Systems

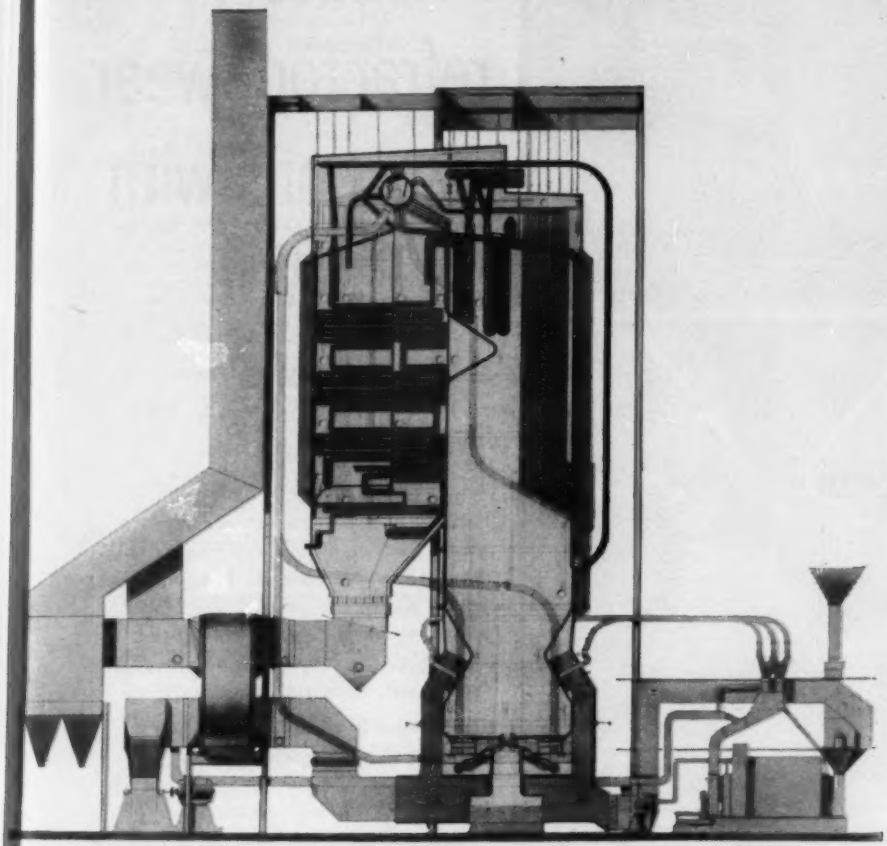
For pulverizing coal Riley offers two types of mills: the Riley Pulverizer and the Riley Ball Mill. These are used with either horizontal Riley Flare Type Gas/Oil/ Coal Burners, or with Riley multiple fuel Directional Flame Burners in Turbo Furnaces. A Riley Boiler installation complete with Riley fuel burning equipment assures Riley's undivided responsibility.

Turbo Furnace Boilers Designed Especially For Multiple Fuels

The Riley Turbo Furnace is ideally suited to firing multiple fuels. When firing coal furnace remains slag-free, flyash disposal is eliminated, carbon loss is negligible. Flame characteristics of gas, oil and coal are similar, simplifying steam temperature control. Available with reheat, non-reheat, with pressurized and non-pressurized furnaces in all capacities and pressures.

A Survey Of Your Plant by A Qualified Consulting Engineer Can Show You Ways To Make

or ALL THREE ?



1,600,000 lbs./hr., 2125 psig, 1005/1005F; Turbo Furnace with Riley Ball Mills; Pressurized Furnace. Fuels — Gas, Oil, Coal

SOME PUBLIC UTILITIES USING RILEY EQUIPMENT

Louisiana Power & Light Co. (3)
Texas Electric Service Co. (3)
Houston Lighting & Power Co. (13)
Dallas Power & Light Co. (3)
Kansas Gas & Electric Co.
Public Service Co. of Indiana, Inc. (12)
New Orleans Public Service, Inc. (3)
The Holyoke Water Power Co.
Columbus & Southern Ohio Elec. Co.
Central Illinois Light Co. (8)
Hartford Electric Light Co.
Central Power & Light Co.
Monongahela Power Company
Arkansas Power & Light Co.
Southwestern Gas & Electric Co.
Utah Power & Light Co. (3)
Florida Power Corporation (2)
Delaware Power & Light Co.
Minnesota Power & Light Co. (2)
Pacific Gas & Electric Co.
Iowa Public Service Co.
Commonwealth Edison Co.
Manila Electric Co.
Southern Nevada Power Co.
Interstate Power Co. (7)
Northern States Power Co.
Central Louisiana Elec. Co. (2)
Union Electric Co. of Ill. (2)
Northern Virginia Power Co.
Union Electric Co. of Mo. (7)
Pennsylvania Electric Co.
Iowa Electric Light & Power Co. (3)
Iowa-Illinois Gas & Electric Co. (7)
Montana-Dakota Utilities Co.
Mississippi Power Company
Philadelphia Electric Co. (4)
Central Ohio Light & Power Co. (6)
Gulf Power Co. (4)
Otter Tail Power Co. (5)
Public Service Elec. & Gas (N.J.) (7)
So. Carolina Elec. & Gas Co. (3)
Taiwan Power Company (2)

Numbers Indicate Repeat Orders

Techniques, Selectivity Of Fuel Burning Equipment Nature of Fuel, Load, and Steam Conditions

Riley Provides Skilled Construction Engineering Services

Riley Stoker Corporation supplies complete construction services. Riley construction crews employ the latest in construction methods and techniques.

Experienced Service Engineers Assist In Maintaining Safe, Efficient Operation Of Your Boiler

Riley Service Engineers are trained for prompt and efficient servicing of all Riley installations. These experienced engineers work closely with your operators.

Riley Stoker Corporation, having successfully met the challenge imposed by the remarkable growth of the public utilities in the past decade is thoroughly prepared to meet the even greater challenges to come.

You'll Find A Riley Office In Each Of These Principle Cities:

Charlotte, Chicago, Cincinnati, Cleveland, Detroit, Houston, Jacksonville, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Salt Lake City, San Francisco, Seattle, St. Louis, St. Paul, Syracuse, Worcester.

RILEY STOKER CORPORATION, WORCESTER, MASS.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

Surprising Savings In Your Power Costs

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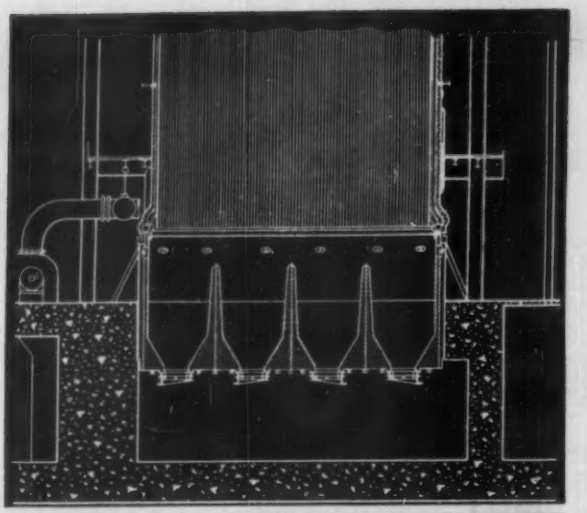
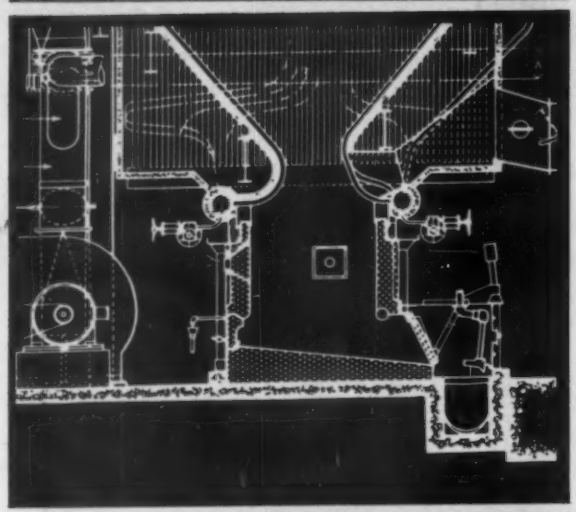
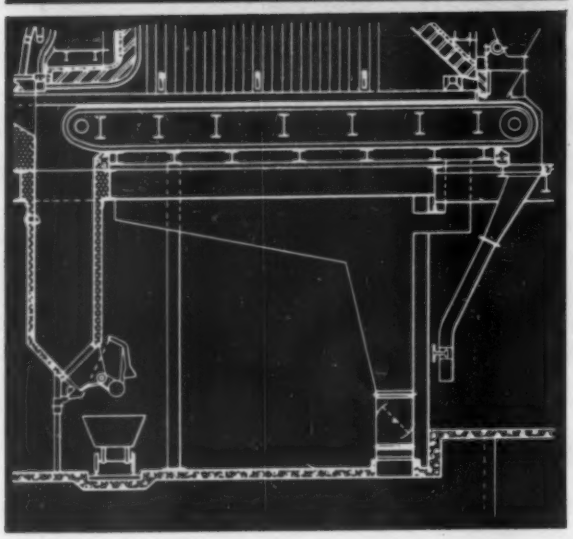


Erosion, due to dry ash sliding down the hopper, is the big problem in this ashpit.



Water jets can cause abrasion of ashpit floor refractories, and water splattered on the walls may cause spalling.



Continuous deposits of ash from a stoker-fired boiler have an abrasive effect on this ashpit lining.

Reduce refractory wear in ashpits with B&W Kaocrete

Relining ashpits is expensive. That's why power engineers specify heavy-duty B&W Kaocrete-D. On job after job, in all types of ashpits, this refractory castable has withstood the heavy abrasive and erosive attacks of sprays, jets, rakes and shovels.

The reason? Specially designed B&W Kaocrete-D has the strength and hardness needed for tough ashpit service. It has unusually high resistance to abrasion, erosion and spalling. It also saves time because it can be cast or gunned in place.

For the facts and figures on Kaocrete-D, as well as Kaocrete-A which is recommended for less severe applications, consult your local B&W Refractories Engineer.

Send for Bulletin R-40 which gives data on B&W Kaocrete Refractory Castables for lining ashpits.

R-008

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS: B&W Ailmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide B&W Ramming Mixes • B&W Kaowool

For more data circle 516 on Post Card

HELPFUL BULLETINS

BOILERS, GENERATORS

101 Packaged Steam Generator — The performance story of company's prototype stoker-fired packaged steam generator in one typical installation is told in 8-pp Bulletin PG-59-4. A detailed evaluation of performance is presented. Foster Wheeler Corp.

102 Wet Back Boiler—Bulletin B-3232 describes a two-pass unit for heating and power featuring complete wet back construction. Includes design details, specifications and range of sizes, and two supplements to the bulletin—Bulletin B-3232-A and B — give rating data, tables of dimensions and dimensional diagrams. The Titusville Iron Works Co.

103 Three-Pass Unit — Featured in Bulletin B-3240 is a three-pass power and heating unit with all wet back construction. In addition to mechanical and thermal features, results of operational tests given. The Titusville Iron Works Co.

104 On Recirculated Gas — Bulletin G-96, 18 pp, contains detailed information on recirculated gas and its relation to boiler design and operation. Discusses thermodynamic effect of recirculated gas, mixing of recirculated with combustion gas and its application to boiler design and operation. Line and bar graphs and boiler drawings supplement text. The Babcock & Wilcox Co.

WATER CONDITIONING

105 Deaerating Heaters — Eight-pp Bulletin WC-101C discusses principles of deaeration, deaerator operation, standard designs available, design features and accessory equipment. It is illustrated with drawings and photos of typical installations. Graver Water Conditioning Co.

106 On Zeolite Softeners — This water conditioning data sheet, "Care and Operation of Zeolite Softeners" covers bacterial fouling, deposits encountered and operational factors in relation to this equipment. It tells too, how exchange materials should be handled to maintain maximum efficiency and longer equipment service life. Betz Laboratories, Inc.

PIPING AND VALVES

107 Recommended Piping Practice — Suitable for posting on bulletin board, this wall chart is divided into five sections covering basic valve types, connections normally used, installation and maintenance tools, installation, operation and maintenance. Illustrations of valves, engineering specialties and lubricating devices appear on back. Lunkenheimer Co.

108 Pressure Reducing Valves — Single-seat, pilot-operated pressure reducing valves are featured in this product bulletin. Installation data, valve operation, dimensions are covered, and photos, drawings, capacity charts included. Atlas Valve Co.

109 Solenoid Valves — Included in this 8-pp booklet on specifying solenoid valves are sections on nomenclature and a description of various types of valve sealing; a discussion of mechanical specification criteria including application description, fluid characteristics, pressure, capacity, leakage, valve life, speed of operation, and envelopes; electrical specification criteria including explanation of solenoid, duty, electrical connections and coil construction; environmental specification criteria. Valcor Engineering Corp.

110 Surge Relief Valve — Bulletin SEW-1 describes a sewage surge relief valve designed to prevent damage from overpressure in sewage lines. Drawings illustrate important features and tables list data on materials, dimensions, specifications. Golden-Anderson Valve Specialty Co.

111 Specialty Valves — Catalog 59 contains sections covering free flow reverse current valves for turbines, refinery and other services; spring relief valves for steam and general services, atmospheric relief valves for condenser service; nonlubricated plug valves for general service, diaphragm operated and pressure regulating valves and by-pass valves, valves for special services, other applications. Complete catalog or its sections are available. Atwood and Morrill Co.

112 Ductile Iron Regulators — Bulletin J-DI describes characteristics and advantages of ductile iron regulators and control valves which combine strength of steel with corrosion resistance of cast iron. Composition, properties, specifications, comparison tables on steel, cast iron and red brass, and test results are covered. OPW-Jordan.

113 For High Pressures — Dimensional data and type drawings for stainless steel taper seal valves and fittings are included in 12-pp Catalog 759. Describes specific applications for pressures of 15,000 psi, and gives envelope dimensions, applicable tubing sizes, standard connections data. High Pressure Equipment Co., Inc.

114 Corrosion Calculator—This detailed calculator, showing preferred materials for different types of corrosives, is designed as a guide to the selection of materials of valve construction, based on "substantial", "moderate", "questionable" or "inadequate" resistance to the chemical in question at atmospheric pressure and temperature. Also lists control products for handling corrosive fluids. Hoke Inc.

HEATERS

115 Storage Water Heaters — Design, operation, construction features and installation specifications of a gas-fired storage water heater are presented in 20-pp Bulletin 4. Diagrams and schematic drawings define three basic systems — gas-burning unit, forced circulation transfer fluid system, and service water system. Design specifications, weights, dimensions, capacities and materials of construction outlined. The Patterson-Kelley Co., Inc.

116 Water Heaters — Large volume water heaters designed to supply hot water for all types of high demand installations are featured in 26-pp Form CH-650. Describes copper coil heaters, underfired heaters, tanks and accessories, and includes sizing data, recovery data, piping diagrams, tank hook-ups, typical installations. The Cleveland Heater Co.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Cards provided on pages 115 and 116.

PUMPS, COMPRESSORS

117 Centrifugal Pumps — Bronze and iron centrifugal pumps with capacities to 320 gpm and pressures to 40 psi are described in 6-pp Bulletin 1004. Performance data on clockwise, counter clockwise, and reversible pumps are included with specifications. Marine Products Co.

118 Turbine-Type Pumps — Eight-pp Bulletin S-111 illustrates and describes features and applications of turbine-type pumps in capacities to 150 gpm. Exploded views, selection tables, limitation charts, dimensions, construction specifications, and detailed engineering specifications are included. Aurora Pump Div., The New York Air Brake Co.

119 Centrifugal Compressors—Three styles of company's single-stage scroll casing compressors — the B style close-coupled, the C style pedestal mounted, ball bearing, and the D style bracket-mounted, pivoted-shoe bearing single-stage centrifugal compressors — are illustrated and described in 12-pp Bulletin 16 B 6048 C. Allis-Chalmers Mfg. Co.

120 Unit-Type Compressors—Again available to power engineers is 12-pp Bulletin SG-2 on unit type compressors. Illustrated in color, this bulletin uses photos and cutaways to describe single- and two-stage compressors from ½ to 15 hp, available pressures from 80 to 250 psi. Specifications list cfm displacements, pressures, weights, dimensions and rpm. Also covered are parts and accessories. Air receiver and auxiliary storage tank specifications included. Le Roi Div., Westinghouse Air Brake Co.

PACKINGS

122 Molded Packings — This 8-pp engineering bulletin presents technical information on the T-shaped form of Palmetto molded packings, the G-T ring. Includes service recommendations, specifications and application data. Lists 88 packing sizes available for use as piston seals, 68 sizes for rod seals. Typical applications are shown in schematic diagrams and cutaway drawings. A reference chart covers a variety of compatible fluid services, temperature ranges, specific packing compounds, selection of component back-up rings. Greene, Tweed & Co.

123 Mechanical Packing Guide — This 64-pp catalog, Form PK-131A, contains comprehensive information on me

chanical packings and is generously illustrated with photos, specification charts, tables. Each packing style carries a symbol to aid in quick identification of media the particular packing will best serve against. Includes chemical selection chart which lists more than 700 liquids common to process industries. Also featured is a simplified packing selection chart to help relate particular operating conditions to the most suitable packing construction style. A section of book is devoted to determining trouble spots. Johns-Manville.

ELECTRICAL

124 Motors and Generators — Featured in this 6-pp bulletin are squirrel-cage a-c motors, special purpose motors, wound-rotor motors, direct current motors, generators and motor-generator sets. Photos and descriptions of the various models are included. The Imperial Electric Co.

125 Medium Transformers — Bulletin GEA-6984, 12 pp, describes transformers available from company's medium transformer department. Construction features and applications for medium transformers, open and sealed dry-type transformers, distribution equipment transformers and integral distribution centers are included. General Electric Co.

126 Improved Cables — Varnished Dacron glass insulated cables are described in 12-pp Bulletin WC-8319, illustrated in color. Stresses advantages afforded by use of varnished Dacron glass tape insulation — longer life, smaller diameter, greater current carrying capacities etc. Physical and electrical properties of the insulation are presented, and full specification data on company's interlocked armor cable design included. General Electric Co.

127 Why Plastic Conduit — Advantages of using plastic conduit in a variety of electrical applications are detailed in this 6-pp bulletin. Mechanical, physical and electrical properties and other specification data are tabulated and installation discussed. Southwestern Plastic Pipe Co.

128 Circuit Breaker Accessories — Twelve-pp Bulletin GEA-6757 describes a line of industrial molded case circuit breaker accessories and modifications for a variety of control applications. Includes detailed selection data, specifications and outline dimensional drawings. General Electric Co.

129 Non-Reversing Starters — Publication ED-30, 8 pp, covers non-reversing combination starters through NEMA size 4. Data provided includes description, photos and enclosure dimensions for popular combination starters with either motor circuit switches or circuit breakers. Cutler-Hammer Inc.

130 Safety Starters — Booklet B-7322, 12 pp, discusses six important safety features of manufacturer's Type L combination safety starters. Type L starters, designed to meet JIC recommendations, are used to control industrial equipment. Also described is "monkey proof" handle mechanism kit available for existing control systems. Westinghouse Electric Corp.

131 Power Control Units — Featured in 8-pp Bulletin S-1075 are power control units utilizing magnetic gating amplifiers driving silicon controlled rectifiers. Details given include circuit operation, applications, illustrations of transfer characteristics, unit schematics, and typical servo systems employing the units. Magnetic Amplifiers, Inc.

132 Interrupting Capacity Chart — This chart aids in selecting and ordering the proper circuit breaker for each application. In addition to interrupting ratings, chart tables of available fault currents are included. Westinghouse Electric Corp.

133 Power Capacitor Units — Bulletin GEA-6990, 12 pp, gives detailed information on construction features of power capacitors and in-line and twin-cluster pole-top equipments designed to provide fixed and switched capacitor banks for distribution circuits. Includes illustrations, graphs, dimensional drawings, wiring diagrams plus complete ratings, weights and dimensions. General Electric Co.

134 Low Maintenance Resistors — Bulletin 6715 shows construction features of Tab-Weld resistors and explains how these features contribute to minimum maintenance. Also included is selection table covering ratings from 13 to 500 amp continuous for various section lengths. These resistors are suggested for severe-duty jobs where vibration-proof, non-breakable construction is important. The Electric Controller & Mfg. Co., Div. Square D Co.

135 Rectifier Power Supplies — Bulletin GEA-6854 describes a line of silicon rectifier power supplies for electrostatic precipitation applications. Design features, characteristics and construction details are covered, and cutaway drawing, comparison chart, dimensional drawings and rating and weight tables are included. General Electric Co.

136 Renewable Fuses — The first section of 12-pp Bulletin 1320, discusses construction and application features of two types of renewable fuses — ferrule and knife-blade — as well as renewal links to facilitate replacement. Salient features are highlighted by sectional and cutaway drawings. Ordering information and specifications of the 250-v and 600-v fuses are covered in the catalog's second section. Ratings from 3 to 600 amp are tabulated. Also featured are current-time curves for fuses from 30 to 600 amp. Federal Pacific Electric Co.

137 Stationary Batteries — Instructions for installing and operating stationary-type industrial storage batteries — particularly lead-antimony alloy batteries of low specific gravity — are presented in 12-pp Form 4676. Tables of ratings, photos and drawings are included. Exide Industrial Div., The Electric Storage Battery Co.

138 Hook-On Volt Ammeter — Bulletin GEA-6292C gives description, specifications and construction details of a pocket-size, hook-on volt ammeter for testing a-c voltages. Lists applications, current ranges, accuracy percentage and operating instructions and other data. General Electric Co.

139 Watthour Meter Tilt — Problems posed by tilted meters and solution provided by company's magnetic suspension meters are detailed in 8-pp Bulletin GEA-6683. Other advantages of the magnetic suspension meters are also covered. General Electric Co.

140 Crane, Hoist Electrification — Bulletin 76 shows company's trolley busway electrification systems in varied crane and hoist installations. Advantages of the prefabricated units are detailed and ratings listed. Feedrail Corp.

141 Connection Fitting — Advantages of the W-S Fishmouth for making branch connections are illustrated and described in this 16-pp booklet. Covers cost comparisons, engineering design data, and illustrates typical installations. Forge and Fittings Div., H. K. Porter Co.

COMMUNICATION

142 Recording Annunciator — Bulletin 102A on company's recording annunciator illustrates both large and small systems, printer and the directly readable alpha-numerical digital tape which requires no decoding. Specification data sheet is included. Panellit, Inc.

143 Annunciator Systems — Comprehensive information on the operation and application of annunciator systems to provide continuous and automatic surveillance of pipelines, chemical and food processing, power generation and distribution is presented in 36-pp Catalog 659. Various types of annunciator sequences are illustrated and described, annunciator diagrams included, and complete engineering data given. The Scam Instrument Corp.

You'll save time in ordering bulletins by using the Reader Service Cards on page 115. Of course we honor letterhead requests—but it takes us somewhat longer to handle them.

144 Data on Annunciators — Profusely illustrated with photos, charts and diagrams, 52-pp Catalog 100C provides comprehensive information on annunciator systems designed to give immediate notification of off-normal conditions in continuous process and automatic machine operations. Discusses function and applications of annunciators and describes types of annunciator equipment, with mechanical and engineering data included. Panalarm Div., Panellit, Inc.

INSTRUMENTS AND CONTROLS

145 Electric Process Control — The complete line of transmitters, transducers, receivers, controllers and final control elements that make up company's integrated system for electric process control is outlined in Specification FS 301-6. The individual devices are covered in detail in Specifications 301-2a through 301-11. Industrial Div., Minneapolis-Honeywell Regulator Co.

146 Analog-to-Digital Processor — Details on a high-speed analog-to-digital processor which acquires, digitizes and stores data are presented in Bulletin 3004A. Operation, design details and specifications are included. Consolidated Systems Corp.

147 Tape Recorder-Reproducer — Bulletin 1576 describes a completely integrated recorder/reproducer system designed to handle a broad range of data storage problems. Physical and operating features are detailed and a 6-pp specification sheet is included. Consolidated Electrodynamics Corp.

LIFETIME SERVICE BACKS UP OCOTILLO'S NEW LJUNGSTROMS®

Extremely compact and highly efficient, these baskets of heat transfer surfaces are the heart of the Ljungstrom. (The photo below shows one being lifted into position.) Every inch of these baskets is the approximate equivalent of one foot of a standard tubular heat exchanger. The combined surface of the Ocotillo Air Preheaters provides 263,600 sq ft of heating surface.

The new Ocotillo Power Plant, near Tempe, Ariz., employs four Ljungstrom Air Preheaters for its two 835,000 lbs/hr boilers. Dependability is built into these Ljungstroms, from their corrosion-resistance to their double-life reversible elements (shown in the photo above).

But one of the most important reasons why Ocotillo chose Ljungstrom is Lifetime Air Preheater Service. Throughout the life of each unit (units dating from 1923 are still in operation), Air Preheater engineers make regular calls to inspect the units and keep them in top operating condition.

What's more, Air Preheater provides rapid factory service, too. Here's an example: a customer called on a Friday morning requesting immediate shipment of cold-end seals for an Air Preheater. But regular fabrication time would take until the weekend, when no ordinary transportation would be available.

So Air Preheater went to work. Special trucking was arranged. And by a tremendous effort, fabrication was completed *on the same day the order was received* . . . and the customer received the necessary parts *only ten hours after his initial request.*

Fast response to emergencies and regular inspection throughout the life of each Ljungstrom installation are two of the many advantages Air Preheater provides its customers. Another is expert knowledge of boiler and preheater problems—and how to lick them—gained from over 35 years' experience. Perhaps these reasons explain why nine out of ten preheaters sold today are Ljungstroms.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

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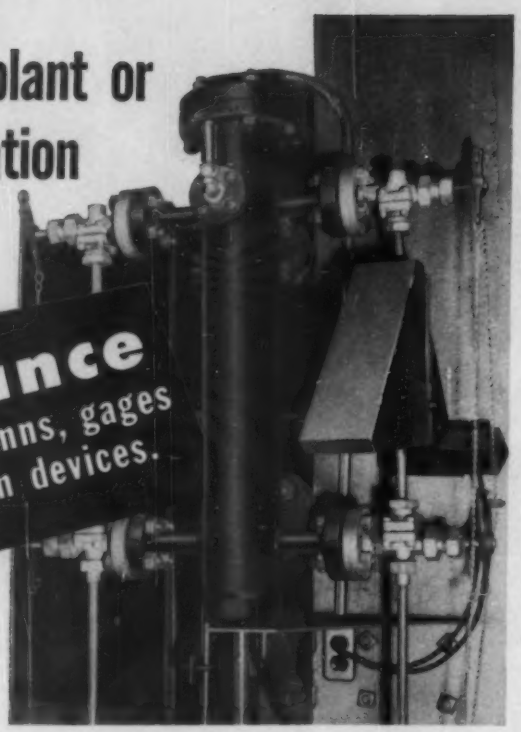
For new plant or modernization

...you'll be wise to select...

Reliance
water columns, gages and alarm devices.



Reliance Alarm Water Column, Twin Gages and Trim

Reliance EYE-HYE Remote Gage

Plan wisely for completely safe water level supervision on all boilers, and all water-containing vessels, with rugged, efficient Reliance equipment. This specialized line includes water columns for any type of boiler — any pressure — and complete trim, including various types of gage valves and inserts, direct-to-drum assemblies and illumination; remote reading gages, auxiliary alarms and automatic controls.

Two most valuable *additions* to your present equipment are the EYE-HYE — safe, sure *manometric* remote reading gage — and the several LEVALARMS which provide instant control of alarms, fuel cut-out and pump operation. If not acquainted with them, write for literature.

Reliance LEVALARM Electrode-type control

Known the world over for accuracy, sturdiness and dependability, Reliance equipment brings you the advantages of trouble-free low-maintenance service. For keeping your plant in the best of trim now, or for planning new or revised power facilities, keep posted on the latest in Reliance Boiler Safety Devices.

The Reliance Gauge Column Co.
5902 Carnegie Ave., Cleveland 3, Ohio

BOILER SAFETY DEVICES
Reliance

1884 75th YEAR 1959

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148 How to Select Recorders — Bulletin GEA-6933, 12 pp, provides buying information on manufacturer's full line of recording instruments, including dimensions and chart speeds, operating specifications, applications, features and accessories. Recorders are grouped by accuracy class. Photos of all models discussed are included. Also described are specialized recording instruments available — recording vibrometers, automatic oscillographs, self-balancing potentiometers, others. General Electric Co.

149 Indicating Panel Meters — Featured in 12-pp Bulletin 107 are indicating panel meters and pyrometers in numerous sensitivities, styles and sizes for monitoring any electrically measurable variable. Lists general specifications and groups meters according to case types. Assembly Products, Inc.

150 Custom Sampling Systems — Publication 651, 6 pp, describes "tailor made" gas sampling systems — company's package method of system selection to provide efficient gas sampling service at moderate cost. Each system is divided into a possible total of eight component packages sections which can be assembled into nearly 16,000 different combinations. Tells how to select components of a specific system and lists typical systems for specific applications. The Hays Corp.

151 Combustion Control Components — Bulletin CC-59 describes company's line of components for combustion control systems, including fuel, air and draft regulators, power units, transfer relays, potentiometer assemblies, remote controllers and fuel control valves. Coen Controls Co., Inc.

152 Malfunction Detector — Technical Bulletin RF-586 describes a malfunction detector designed to provide maximum protection for large motors, pumps, compressors and other rotating equipment by responding to mechanical malfunctions the instant they occur. Specifications are included, as well as diagrams and dimensional data. Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co.

153 Feed Water Control — Two-element and single-element air-operated feed water control systems are illustrated by diagrammatic drawings in Bulletin 531. To aid in selecting proper system for each application, a simplified chart is included. Bailey Meter Co.

154 Test Instruments — Catalog G-10 contains 48 pp of detailed information on a line of scientific measurement, recording, and testing instruments. Among the instruments covered are d-c amplifiers, data handling systems, lab and calibration instruments, magnetic tape instrumentation, nuclear instrumentation, oscillographs, recorders and indicators, servo components, temperature controllers and transducers. Industrial Div., Minneapolis-Honeywell Regulator Co.

LUBRICATING

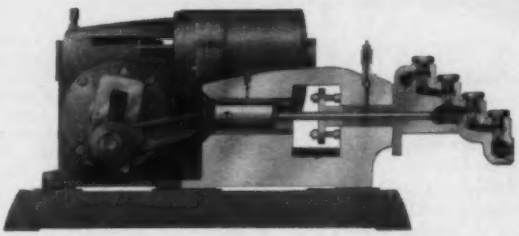
155 Oilers, Oil Controls — Circular 580 describes bottle oilers, oil cups and constant level oil controls. It is packed with illustrations, application data, and dimensional specifications covering automatic constant oil level controls; bottle oilers for plain bearing lubrication; glass

HOW TO METER SLURRIES ACCURATELY

Few pumping jobs present more complex problems than the accurate metering of slurries. Since they are often abrasive, slurries can make the selection of pump parts extremely difficult. Minute particles settling out in the packing can score a plunger beyond usefulness in minutes. And viscous, tacky slurries can limit ball check freedom and reduce accuracy. But even the toughest slurries *can* be metered accurately . . . by adhering to good slurry handling practice, and by choosing the right pump for the job.

Keep Slurries In Suspension

Several practices that have proved valuable in this difficult service are aimed at keeping the solids in suspension. Suction and discharge lines should be as short as possible. The supply tank should always be well agitated. And if packed plunger pumps are used, stroking speed should be held between 45 and 75 rpm to minimize settling.



Standard Motor Driven Controlled Volume Pump

Choosing The Right Pump

Controlled volume pumps are manufactured in a sufficient variety of designs to provide a full range of desired characteristics for slurry service. An economy pump such as Milton Roy's H20® can handle slurries up to 5% by weight. Standard motor driven pumps, with minor modification, can handle much denser slurries. And the new ODS (Oliver Diaphragm Slurry*) controlled volume pump can easily manage slurries containing up to 60% solids by weight.

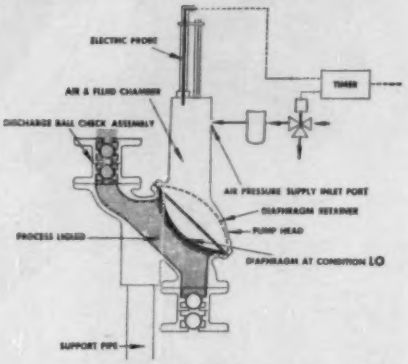
*Manufactured under exclusive license granted by Dorr-Oliver Inc.

Packed Plunger Pumps

Because the entire liquid end of a packed plunger pump is in intimate contact with the slurry, considerable attention must be paid to materials selection. Ball checks and plunger should be as hard as possible, and seats should be relatively soft. Balls are usually made of Hastelloy D, 440 stainless, or ceramic, while 316 stainless is standard for the seats. The plunger must be extremely hard, and high strength sintered alumina is generally recommended.

Proper packing maintenance in slurry service demands that packing be flushed out continuously. An internal flush, continuously bleeding a small amount of liquid along the plunger, is the most common. Dangerous liquids may require an external flush arrangement. Liquid is continuously fed in on one side of the lantern ring, drawn around the plunger, and carried away from the other side.

The ODS Controlled Volume Pump



Capable of pumping 180 gph of the densest slurries at accuracies of ± 2% against pressures up to 90 psi, the ODS has no plunger, no packing. It is based on the Oliver Diaphragm Slurry pump design principle which consists of two opposed chambers separated by a slack diaphragm. A three-way solenoid alternately pressurizes and bleeds air from the upper chamber. With the upper chamber at atmospheric pressure, the suction head forces slurry into the lower chamber. Then, when the upper chamber is pressurized, the diaphragm forces the slurry out through the specially designed ball check valves.

Problem Slurries

Yes, slurries *can* be metered accurately. And the best proof of this claim is the thousand or more Milton Roy pumps successfully metering slurries in the field. The list includes such problem liquids as an 80% coal slurry, a 45% suspension of lead peroxide in butyl phthalate, 15 to 20% diatomaceous earth slurries, finely divided nickel catalytic suspensions, gold ore slurries, and even a 55% by weight powdered aluminum suspension. Some of these materials are so thick that they can support the weight of a screwdriver.

If precision metering of slurries is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solutions. Write for a general introduction to controlled volume pumping given in Catalog 553-1, Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

milton Roy
CHEMICAL INSTRUMENTATION SYSTEMS

Controlled Volume Pumps • Quantichem Analyzers • Chemical Feed Systems

For more data circle 519 on Post Card

ROTOJET®
Tube Cleaners

Clean tubes and pipes from ½" to 12" I.D. THOROUGHLY QUICKLY

ROTOJET Model 512 Air-driven Motor, universal joint, swing-frame head, and solid brush.

Our large stock of Rotojet air-driven and water-driven tube cleaners, accessories, and repair parts for straight and curved tubes, pipes, and transfer lines is available to meet most requirements without delay. Tube cleaner specialization for 43 years assures satisfactory results from any Rotojet equipment we recommend. Send for Bulletins J-410 and R-105. For quick action wire or phone, HUmboldt 3-0570.

ROTOJET Model C-526 Air-driven Motor with pivot head and universal joint.

ROTOJET Model C-525 Air-driven Motor with swing-frame head and universal joint.

ROTOJET Junior Model S32 Air-driven Motor, universal joint, cone cutter.

ROTOJET Junior Model C434 Air-driven Motor, flexible coupling, expanding brush.

ELLIOTT COMPANY – ROTO PLANT
Tube Cleaner Specialists Since 1910

147 Sussex Avenue, Newark, N. J.

For more data circle 520 on Post Card

body and aluminum body oil cups. Lunkenheimer Co.

156 Electrical, Lubricating Aids — Condensed Catalog 59 contains 12 pp packed with descriptive data covering types and use of company's electrical and lubricating devices, and includes recently developed products. Presents automatic oilers, chain oilers, mist systems, industrial fuses and fuse accessories. For easy reference, all items are listed with catalog numbers, capacities, sizes, other data. Trico Fuse Mfg. Co.

OTHER EQUIPMENT

157 Generating Plants — New high capacity units are among electric generating plants described in this company's 8-pp 1960 general catalog, No. F-146. Lists more than 45 basic models of gasoline and diesel engine-driven generator sets. Each series is described in detail with specifications for both engine and generator. A chart of representative models within each specific series shows capacities, model numbers, voltage, starting method, dimensions, weight. D. W. Onan & Sons Inc.

158 Elbow Fans — Bulletin VEF-59 describes elbow fans for handling clean, contaminated, hot or explosive air or fumes at normal or elevated temperatures. Contains tables of sizes and dimensions, selection data and capacity tables. L. J. Wing Mfg. Co.

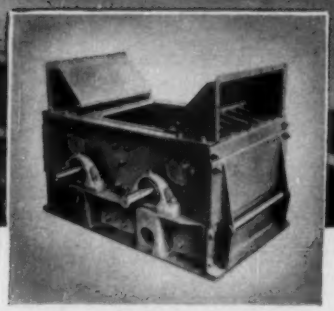
159 Worm Gear Reducers — Single-reduction worm gear speed reducers with a new high-load-capacity thread form are described in 32-pp illustrated Catalog 3805. It covers Delroyd reducers utilizing worm and gear materials permitting maximum ratings allowed by AGMA rating standard. Four types are presented: one for 2½- to 4-in. centers, adaptable to any mounting position; and types for bottom drive, top drive and vertical mounting, all for 5- through 12-in. centers. Catalog gives information on advantages of worm gears, and how to select them; includes specifications, horsepower and torque ratings, capacity and dimensional data. De Laval Steam Turbine Co.

160 Fiber Glass Insulation — Engineering dimensions, physical and electrical properties and prices for the Glastic line of insulators molded from fiber glass reinforced polyester are presented in this product bulletin. Advantages are detailed. The Glastic Corp.

161 On Rigid PVC — Catalog RV-59, 24 pp, gives detailed information on rigid polyvinyl chloride products, their properties and applications. Presents data on plate, joining accessories, extrusions, bolts and nuts, and calendered sheeting. Includes chapters covering physical properties and chemical resistance of rigid PVC. A section on applications illustrates use in exhaust hoods and ventilating equipment etc., lists industries in which it is particularly advantageous. Kaykor Industries, Inc.

162 Silicone Rubber Compounds — Product and application data on RTV (room temperature vulcanizing) silicone rubber compounds is provided in 12-pp Bulletin CDS-170A. These compounds are used for potting and encapsulating of electrical and electronic equipment, for high low temperature sealing, other applications. Booklet contains recent information on proper product properties and

STEPHENS-ADAMSON

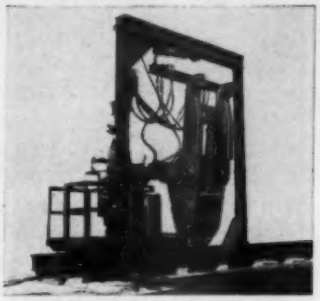


S-A RING TYPE, DOUBLE ROTOR KNITTEL CRUSHER — Crushes lumps while in suspension. Maintains full capacity with wet coal — no clogging. Greater capacity — less space required.

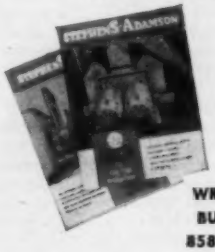
COAL HANDLING SYSTEMS
increase tonnage, lower costs!

When STEPHENS-ADAMSON engineers and builds a coal handling system, over a half-century of "know-how" in the design of unloading, storing, crushing, reclaiming, sampling, and distributing systems is put to use. S-A experience dates back as far as the early beginnings of electric power and includes the engineering of giant systems such as the mammoth Detroit-Edison and New York State Electric installations to a newly engineered power plant in Bombay, India. Large or small, an S-A engineered system means more kilowatts per ton and years of dependable service.

Backing up the "know-how" and experience is a quality-engineered line of components, each providing an exclusive combination of features — many of them carrying patents by S-A engineers. Put S-A engineering skill to work for you . . . write for full information today!



S-A HYDRAULICALLY POWERED CARQUAKE — Maximum efficiency in unloading hopper cars with minimum noise. One man operation. No expensive overhead structures — a completely self-contained unit.



WRITE FOR BULLETINS 858 and 658

S-A
MATERIALS HANDLING PRODUCTS
SEALMASTER BALL BEARING UNITS

ENGINEERING DIVISION
STEPHENS-ADAMSON MFG. CO.
GENERAL OFFICE & MAIN PLANT, 86 RIDGEWAY AVENUE, AURORA, ILLINOIS
PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA • CLARKSDALE, MISSISSIPPI
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WESTERN CHEMICAL COMPANY
Kansas City 5, Mo.
Pioneers in the chemical control of problems relating to the use of water, steam and fuel

"I have a problem..."

- ☐ scale, corrosion, or foaming in my boiler operation
- ☐ rust and corrosion in my steam and condensate return lines
- ☐ scale, corrosion, or algae growth in my cooling or condenser water system
- ☐ corrosion or scale in my potable or plant water supply lines and tanks
- ☐ rust and corrosion in my brine or sweet water system
- ☐ scaled up pumps, water jackets, compressors, coils, lines, or equipment
- ☐ sludge and moisture in my fuel oil supply
- ☐ soot deposits in my furnace combustion areas

"I'd like to know..."

. . . exactly what specific treatment your Technical Services Dept. recommends. I understand that such problems have been your specialty for over 65 years and that you have an outstanding record for restoring and maintaining efficiency of plant equipment through advanced chemical treatment. Will look forward to receiving in the near future both your latest technical literature *and* a personal letter concerning my problem. I understand that my inquiry involves no obligation.

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FIRM_____

ADDRESS_____

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Mail to Technical Services Dept., WESTERN CHEMICAL CO.
717 Washington St., Kansas City 5, Mo.

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data for RVT compounds -20, -40, -60 and -90 and silicone rubber sponge. Also gives suggestions for handling RVT compounds, curing and viscosity characteristics. General Electric Co.

163 Grouting Methods — Effective methods for grouting the different basic types of heavy industrial equipment are explained with text and photos in 8-pp Bulletin EPMG-2A. Advantages of the pre-mixed grout are explained, and diagrams, charts and photos cover preparatory steps, forming, selecting materials, mixing and placing grout. Master Builders Co.

164 Maintenance Equipment— Catalog No. P-9, 24-pp, contains descriptions of pulling systems, photographs showing Grip-o-matic and push-pullers, Power-Twin "center hole" rams, pumps and hydraulic shop presses and shows how these units remove and install gears, bearings, pulleys, shafts and couplings simply and quickly. Illustrations and descriptions of heavy duty industrial wrenches included. Owatonna Tool Co.

165 Metal Treatment — Featured in this product bulletin is a metal treatment designed to be applied directly on rusted metal to stop rust action and provide a sound base for maintenance paint. Advantages and application details described. Rusticide Products Co.

166 For Air Supply Lines — Sixteen-pp Catalog 227 illustrates and describes an expanded line of air supply line accessories. Presents sockets, plugs, hose clamps, fittings and tools, all interchangeable with most standard makes. Provides full specifications and includes handy chart showing identification numbering system. Lincoln Engineering Co.

167 Electrical Insulating Varnish — This 36-pp catalog covers the selection and application of electrical insulating varnishes with complete details on all electrical and mechanical properties as well as operating temperature limitations Includes charts, graphs and illustrations on temperature conversion, solvents, specific gravity, viscosity, also specifications. Minnesota Mining and Mfg. Co.

168 Cooling Tower Drive — High-horsepower worm gear drives designed to handle heavy-duty fans under extreme conditions of heat and humidity in cooling tower service are featured in 8-pp Bulletin 135-S. Dimensional data and diagrams, ratings, and installation instructions included. The Cleveland Worm and Gear Co.

169 Spiral Conveyors — Engineering data, conveyor layouts, capacity tables, selection and horsepower requirements on spiral conveyors are presented in 56-pp Catalog 951. Sections devoted to couplings and shaftings, hangers, trough ends, unit drives, thrust bearings and accessories round out comprehensive information provided. Conveyor specification is also detailed and a guide for laying out a standard conveyor is included. Book is generously illustrated with photos, drawings and tables. The Jeffrey Mfg. Co.

170 Moisture Inhibitor—Described in this 6-pp bulletin is an inhibitor that displaces and seals out water and moisture, protects metal surfaces against corrosion, and lubricates, and is designed for use on electrical and electronic equipment. Advantages and applications are detailed, and specifications included. Corrosion Reaction Consultants, Inc.

Stone & Webster Designs

New "Double-Duty" Station for Great Northern Paper

Process steam and electric power for Great Northern Paper Company's No. 1 Mill at Millinocket, Maine, are now produced simultaneously at a single station recently designed and completed on schedule by Stone & Webster Engineering Corporation.

The new plant, with complete centralized control, increases Great Northern's power supply by 36,000 kw and provides process steam at both 210 psig at 480° F and 40 psig at 300° F — with provision made to increase these extraction pressures whenever desirable.

In this, as in every engineering operation, Stone & Webster worked closely with the client's own engineering department to insure the use of all possible construction and operating economies consistent with the most advanced designs and methods available today.

For this skilled assistance on your next engineering project, call or write our nearest office.

STONE & WEBSTER ENGINEERING CORPORATION

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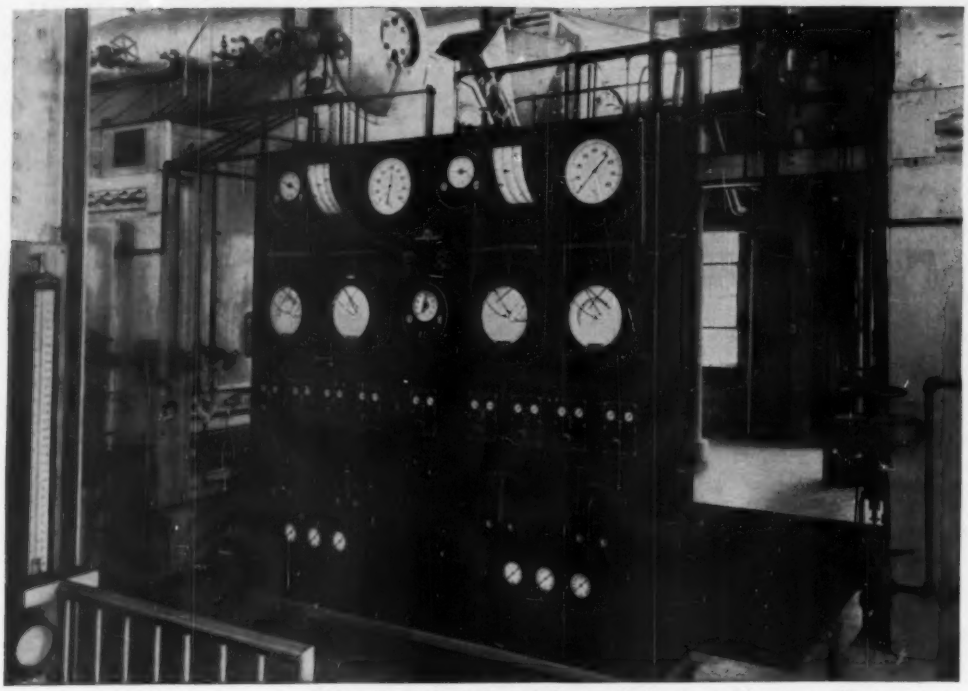

Bailey Meters and Controls for two boilers in a midwestern milling company.

How Bailey helps you get a new boiler off to a fast, safe start——

--The thrill of putting a new boiler "on-the-line" can be marred if you lack adequate metering and control equipment. You are a lot surer of a fast, safe start and dependable operation for a long time when you specify Bailey Meters and Controls. They are keys to peak efficiency and low operating costs.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. A Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs. Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A131-1

Instruments and controls for power and process

BAILEY METER COMPANY

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BAILEY METERS

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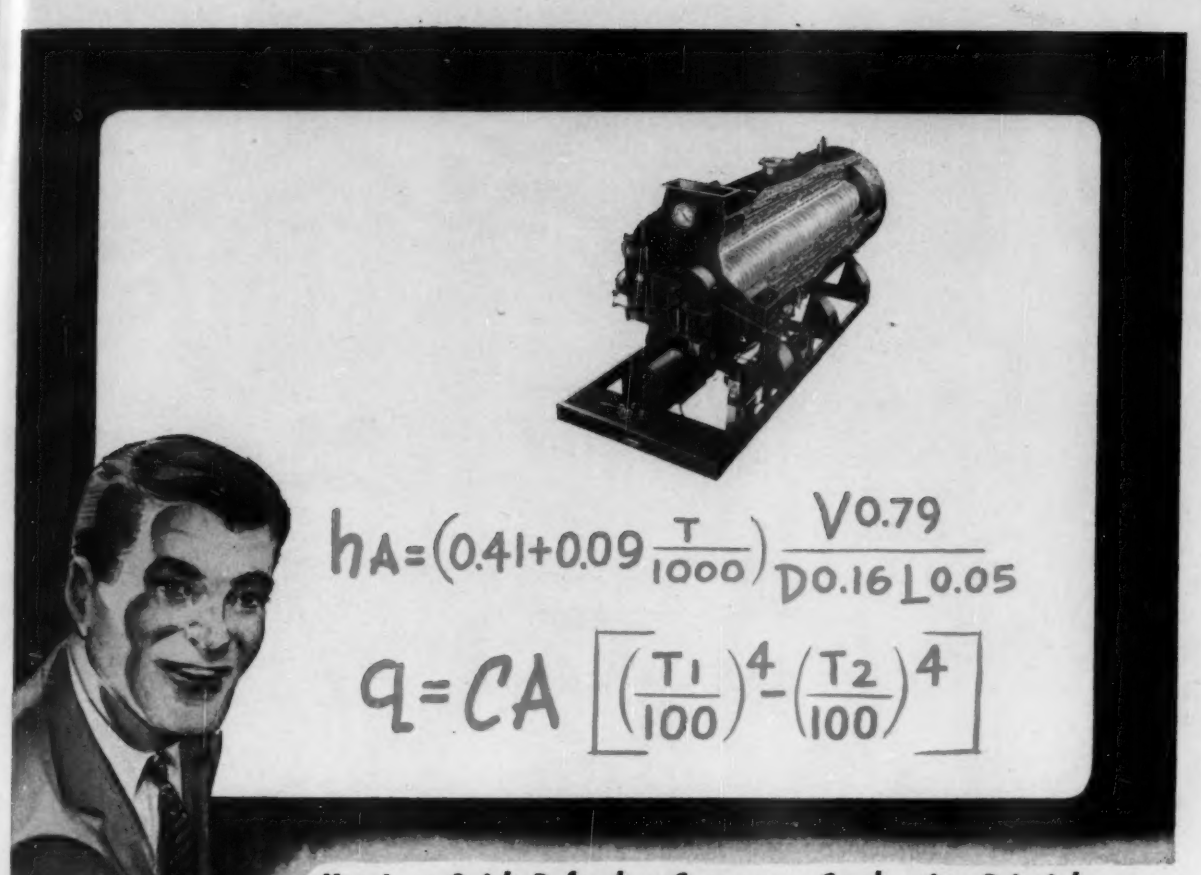

Here's a Quick Refresher Course on Combustion Principles . . .

A Cyclotherm Sound Film-Strip that you and all your engineering friends should see

Every engineer interested in combustion should be sure to see the Cyclotherm sound film-strip, *Heat Transfer and Cyclonic Combustion.* Written by engineers, from a professional, not a promotional, point of view, this film is a quick refresher course in the principles of boiler engineering. *For engineers only* – too many mathematical formulae for the man-in-the-street to follow.

Cyclotherm has also prepared a manufacturing film which shows, step by step, how Cyclotherms are built. Beginning with the flat plate arriving from the steel mills and finishing with the complete boiler shipped to the customer, this film illustrates what we mean when we say that "one manufacturing responsibility is behind the entire equipment."

We'll be glad to arrange for an early showing of both these films. Invite other engineers in your company, as well as members of any engineering group to which you belong. You can see each film in 20 minutes – and you'll find them 20 minutes very well spent. For full information, write us today.

The Cyclotherm manufacturing film almost equals a trip through the Cyclotherm plant.

YEARS AHEAD IN STEAM & HOT WATER GENERATION

CYCLOTHERM®

STEAM AND HOT WATER GENERATORS

A Division of National-U.S. Radiator Corp. 50 E. First St., Oswego, N. Y.

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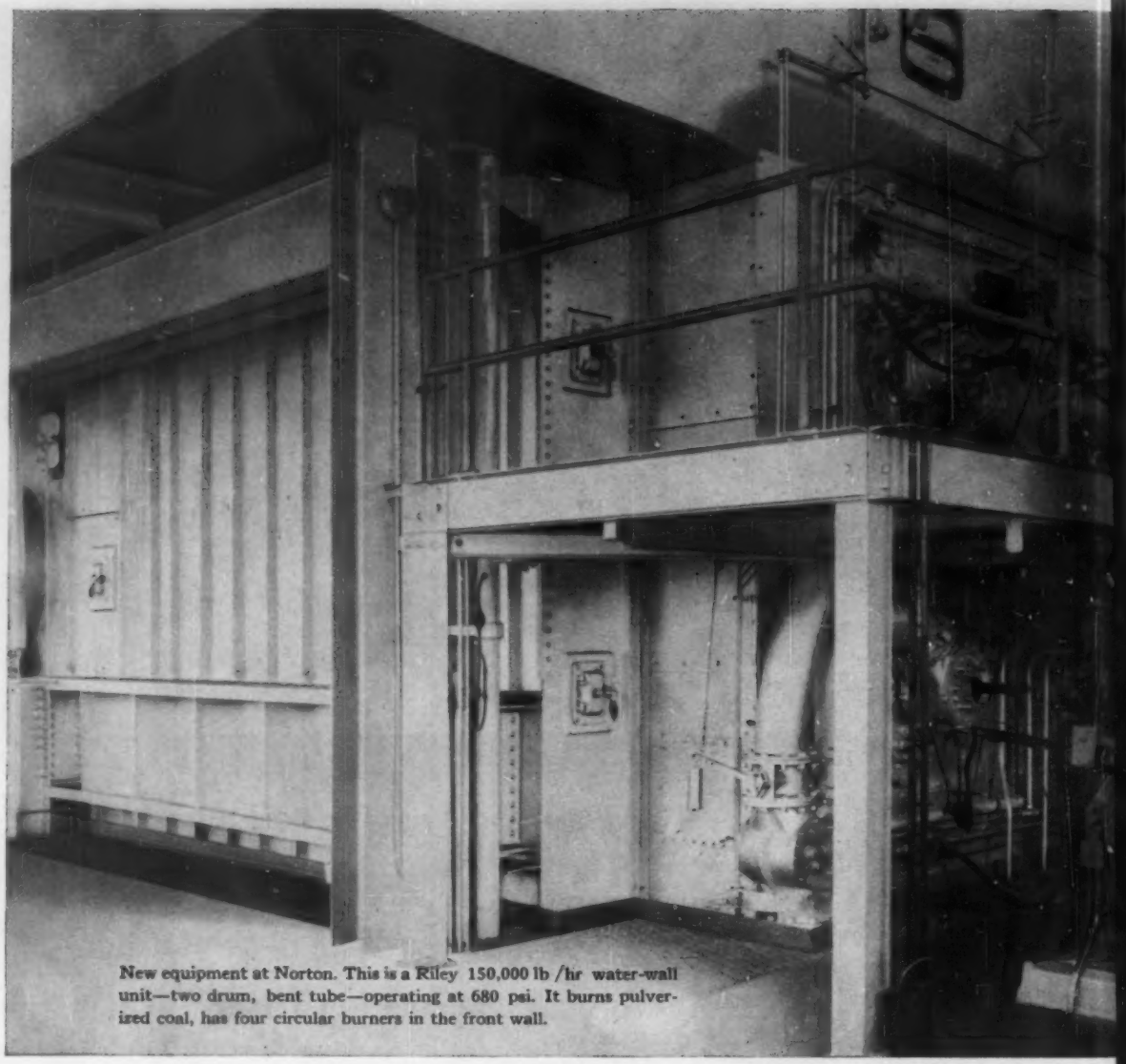


New equipment at Norton. This is a Riley 150,000 lb /hr water-wall unit—two drum, bent tube—operating at 680 psi. It burns pulverized coal, has four circular burners in the front wall.

Coal proves best dollar

NORTON COMPANY FINDS COAL STILL IS LOWEST COST

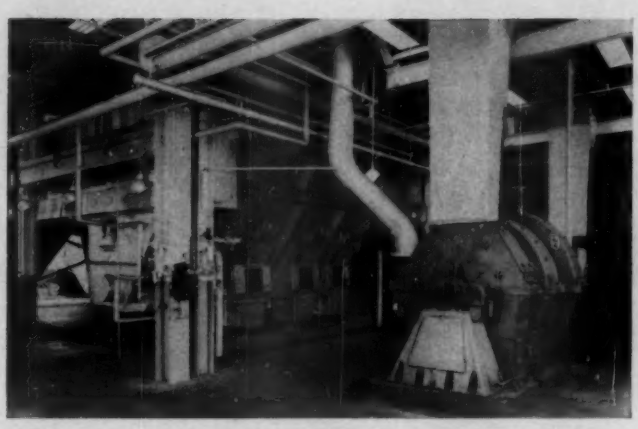
As plant facilities expanded, the Norton Company, Worcester, Mass., world's largest manufacturer of abrasive products, required greater quantities of steam for heating, hot water, electricity and process work. This expansion prompted an engineering survey to determine future power needs. As a result, Norton staff engineers—working with K. R. Warrington, Consulting Engineers—decided to install additional steam generating equipment. Coal had been used previously because it was the most economical of the fuels in that area when the original plant was installed. Coal *continues* as the fuel of the new plant for the same reason. Norton management is sold on the fact that, dollar for dollar, coal is the best fuel buy.

COAL IS LOWEST COST FUEL

Today, ***when the annual cost of fuel often equals the original cost of the boilers,*** you should know that bituminous coal is the lowest cost fuel in most industrial areas. And modern coal-burning equipment gives you 15% to 50% more steam per dollar, while automatic operation trims labor costs and eliminates smoke problems. What's more, tremendous coal reserves and mechanized mining procedures assure you a constantly plentiful supply of coal at stable prices.

CONSULT AN ENGINEERING FIRM

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel



In the center, ash hoppers—part of United Conveyor steam vacuum ash handling system—lead to underground conveyor which moves ashes to outside storage silo. At right: coal pulverizers.

From track hopper, 100 ton/hr boom conveyor (right) carries coal to storage area. Bucket conveyor (center) lifts it to belt conveyor at top of plant. Coal handling system by William T. Donovan Co. and Jeffrey Manufacturing Co.

buy

FUEL IN ITS AREA

costs and equipment—can effect great savings for you with the efficiency and economy of coal.

TECHNICAL ADVISORY SERVICE

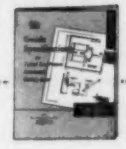
To help you with fuel problems, the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to address below or send coupon. Ask also for case histories booklet, complete with data sheets. You'll find them informative.

BITUMINOUS COAL INSTITUTE

Department PE-12, Southern Building, Washington 5, D. C.

See our listing in Sweet's Files: A-30l/Bi; PE-4a/Bi; IC-18b/Bi

SEND COUPON FOR NEW BCI PUBLICATIONS
Guide Specifications, with complete equipment criteria and boiler room plans:



Bituminous Coal Institute, Dept. PE-12
Southern Building, Washington 5, D. C.

Gentlemen: Please send me:

☐ GS-1 (low-pressure heating plant, screw-type underfeed stoker).

☐ GS-2 (high-pressure heating and/or process plant, ram-type underfeed stoker).

☐ GS-3 (automatic package boiler for heating and process plants).

☐ Case histories on larger plants.

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Company _____

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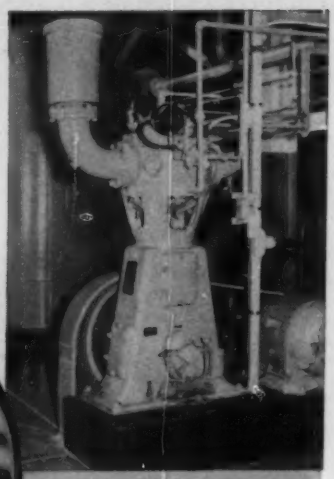
CHROME-PLATED CYLINDER WALLS FOR CORROSION RESISTANCE

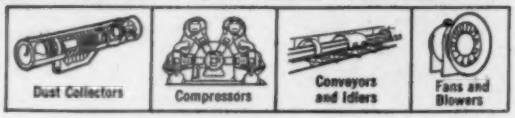


Joy WGO-9 Compressors supply instrument air in southwestern power station.

Chrome-plated cylinder walls give Joy Oil-Free Compressors longer service life and lower maintenance costs. The intermittant duty typical of oil-free compressor service makes rusting of the cylinders a prime source of trouble. Because of the exclusive replaceable cylinder liner construction, Joy is able to put a chrome face on the cylinder wall which will resist corrosion and also give extra wear. This feature and the exclusive T-Block carbon-graphite compression ring construction make Joy Oil-Free Compressors economical to operate.

Joy can supply positive displacement machines with capacities up to 7392 CFM and dynamic machines in any size desired. For complete details on how to get truly low cost, oil-free air, consult your Joy representative, or write for Bulletin 926-56C.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

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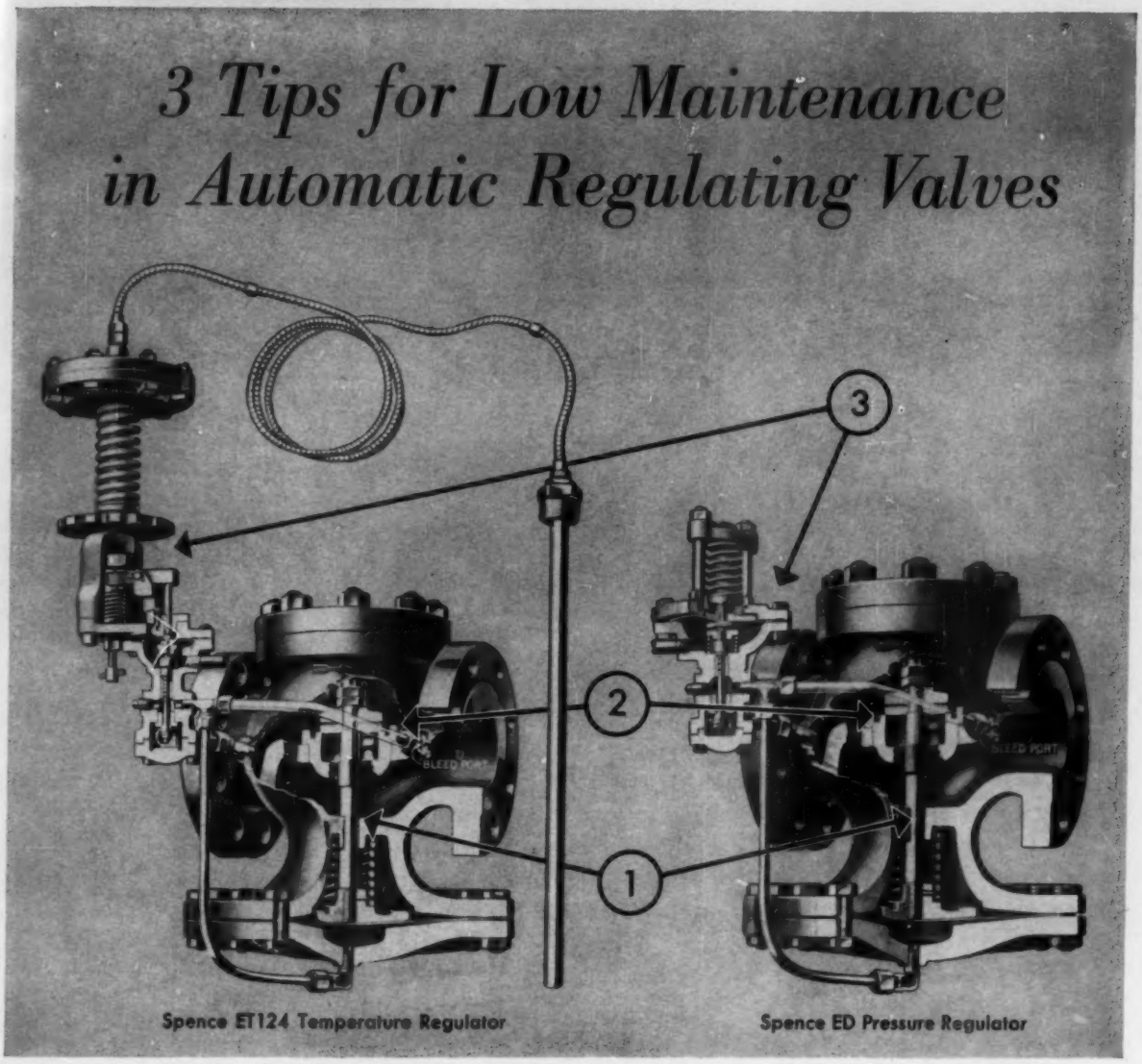
3 Tips for Low Maintenance in Automatic Regulating Valves



Spence ET124 Temperature Regulator

Spence ED Pressure Regulator

No engineer has to be told that downtime of regulating valves is costly—and a nuisance.

Nowadays the men who keep these valves operating want to make sure they aren't stuck with a maintenance headache for the life of their valves. That's why we are outlining this simple check list which covers three important features which keep maintenance costs down.

1. Stuffing boxes are probably the number one time consumer in valve maintenance. No matter how you figure it, repacking stuffing boxes is costly.

That's one reason Spence uses a "balanced" diaphragm construction which eliminates stuffing boxes. Simple stem guiding and large metal diaphragm operation reduce sticking and binding to a minimum.

2. Another problem is replacement of seats and discs when they've been cut by steam. Today you can forget about this problem entirely by insisting on an unconditional guarantee against wire-drawing. Spence, for instance, uses SECO Metal seats and discs and gives such a guarantee.

3. Any valve designed to control temperature and pressure within tight limits can be affected by dirt in the steam lines. You can't get a guarantee against this, but you can specify a valve that makes trouble shooting easy. Here's the tip:

Make sure your regulating valve is controlled by an external pilot. If trouble develops, it is easy to find out if it is in the pilot or the main valve with a simple test.

If the trouble is in the pilot, you can remove it without taking the main valve out of the line.

The quickest way to get the regulator working again is to install a spare pilot. This is easy—and in the Spence design it is not expensive to carry spare pilots. Spence pilots fit all sizes of Spence main valves.

These maintenance advantages plus other advanced features are available in a wide range of Spence automatic regulating valves. For more information write for the Bulletin TE.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York

SE-144

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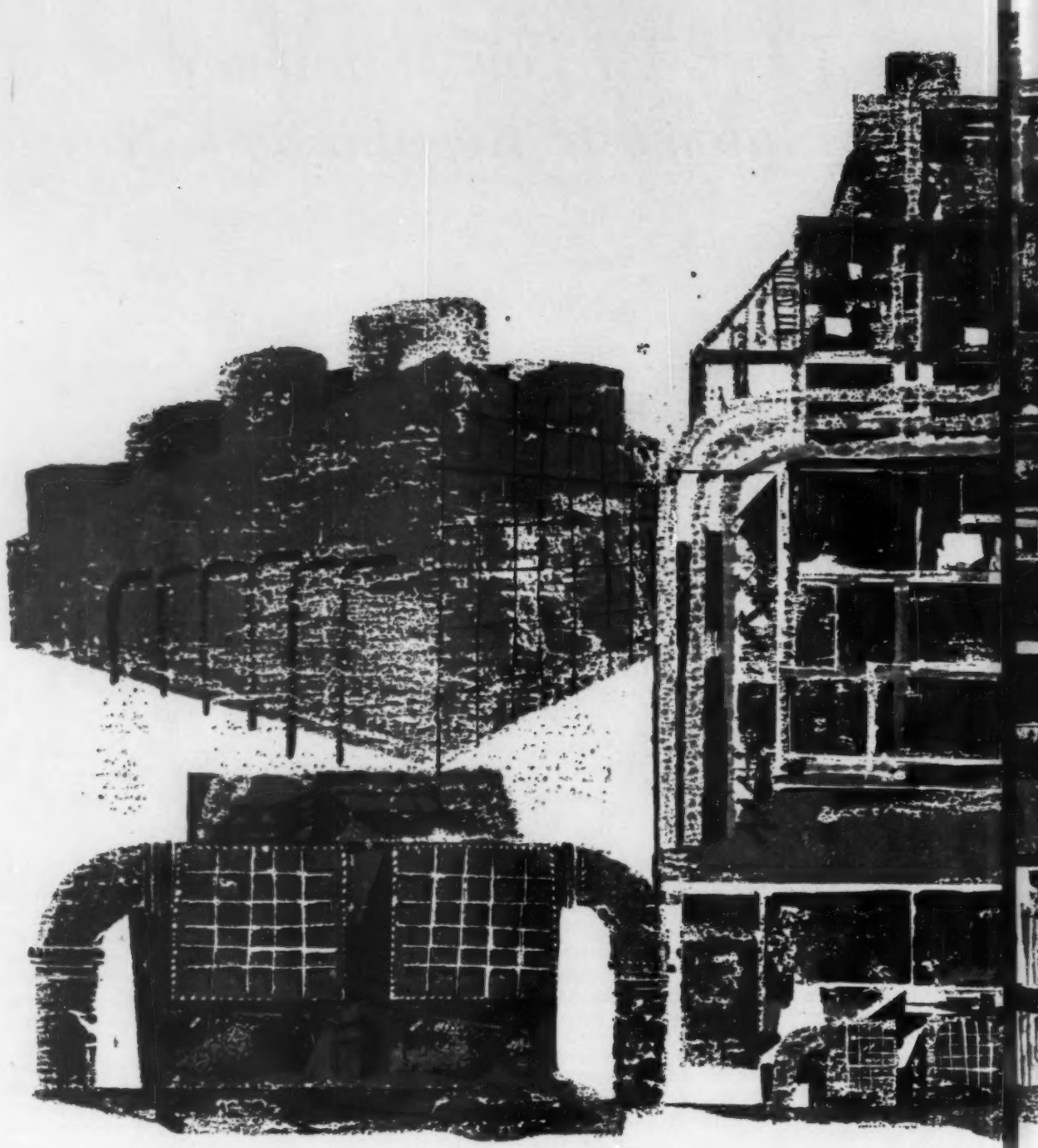

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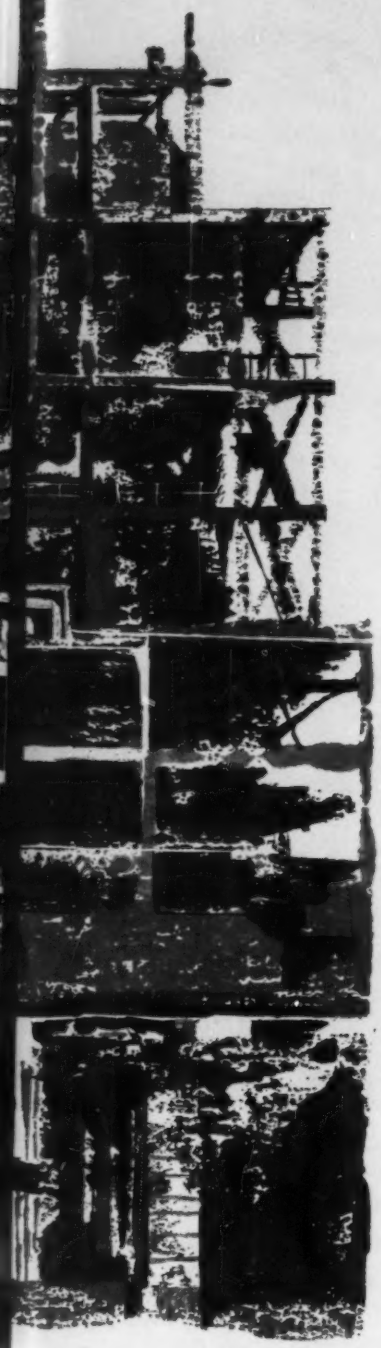

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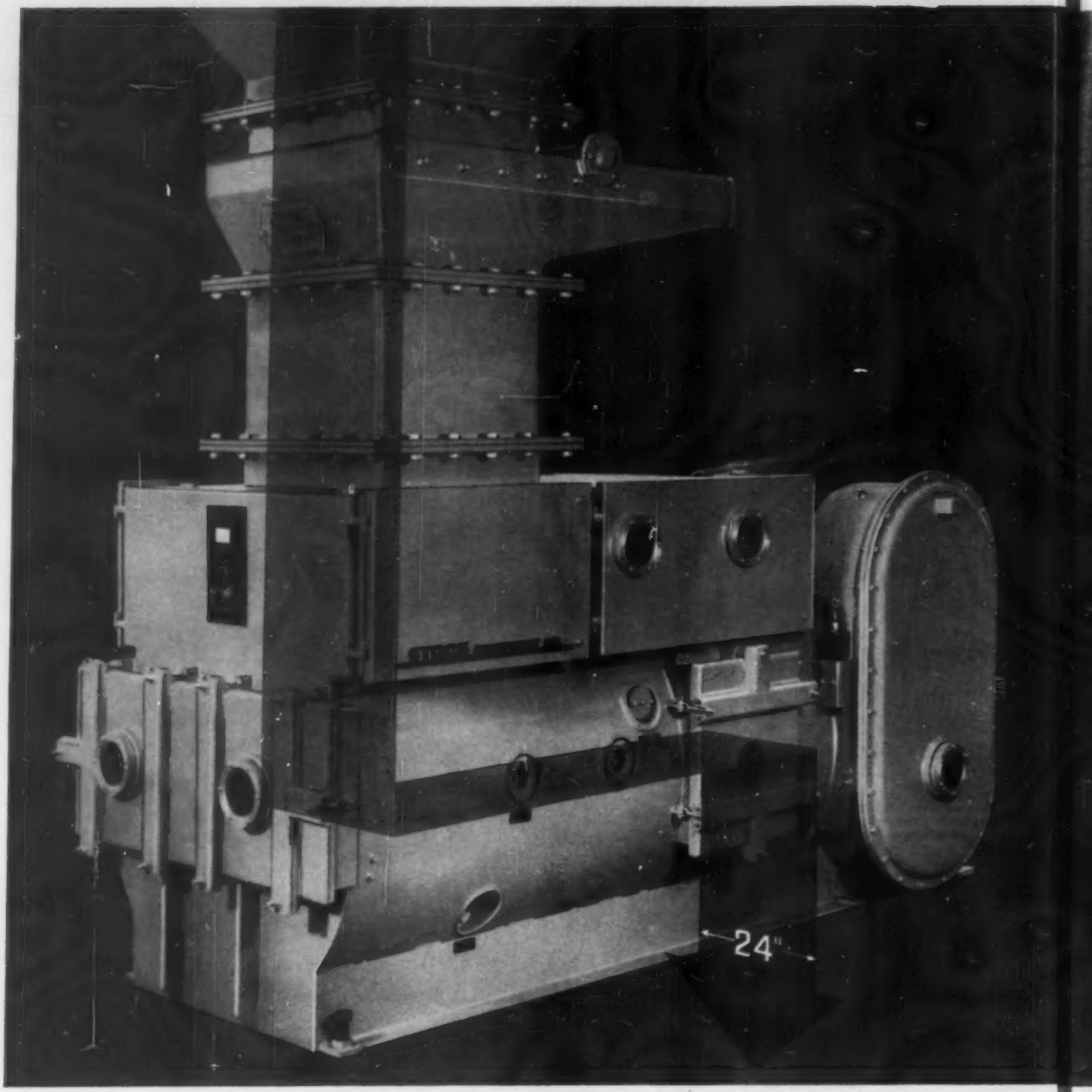

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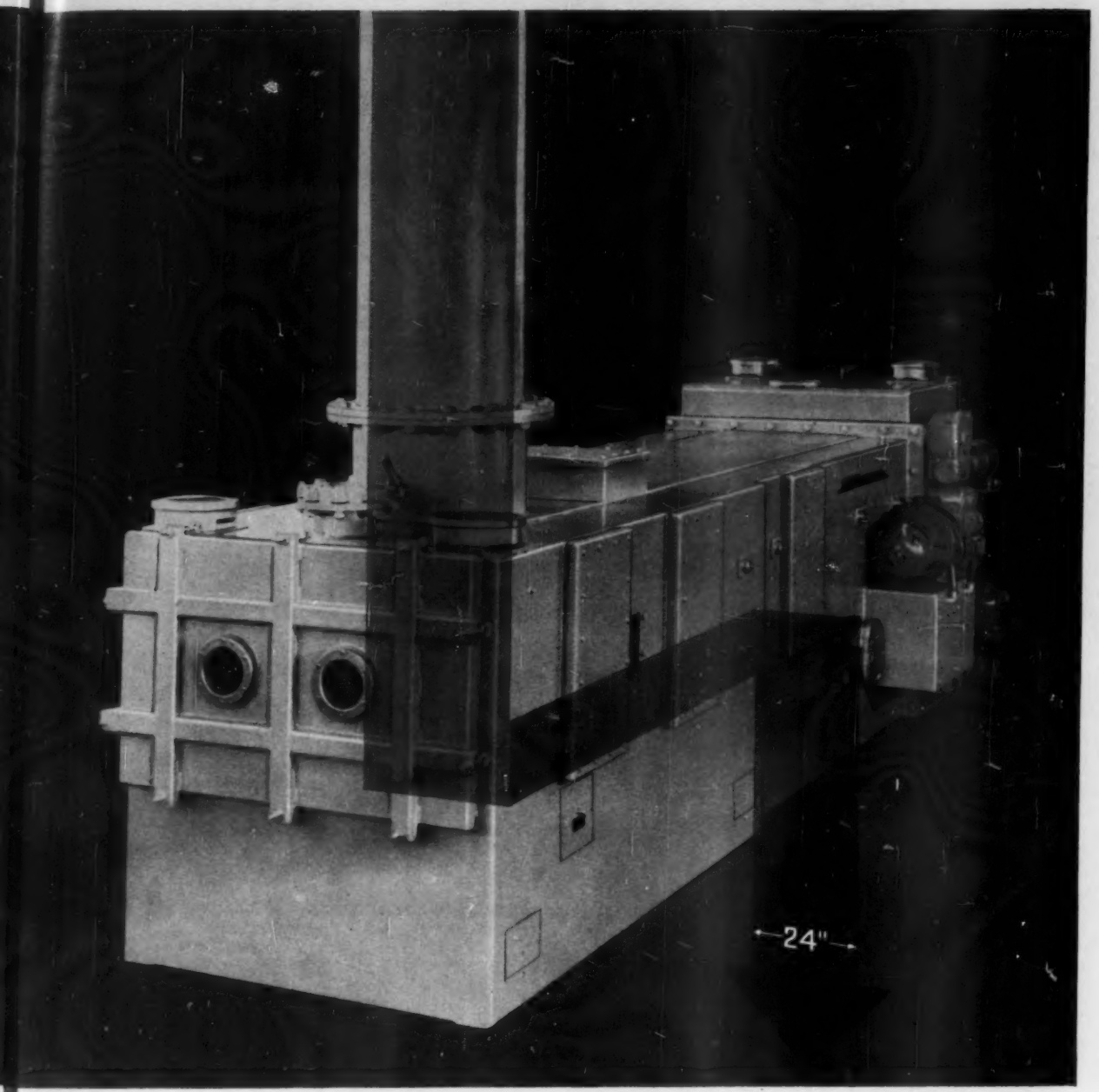

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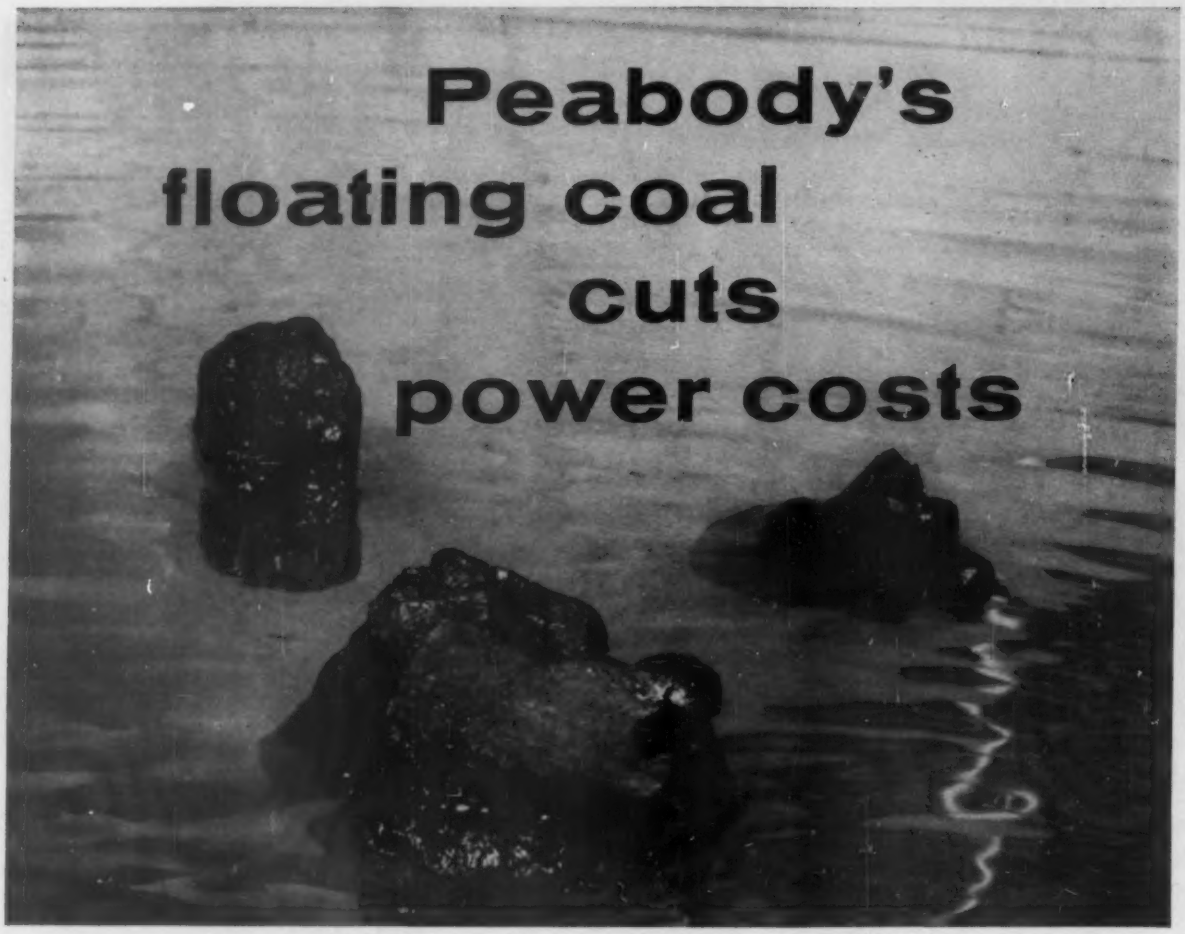

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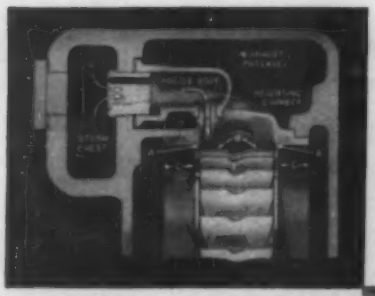

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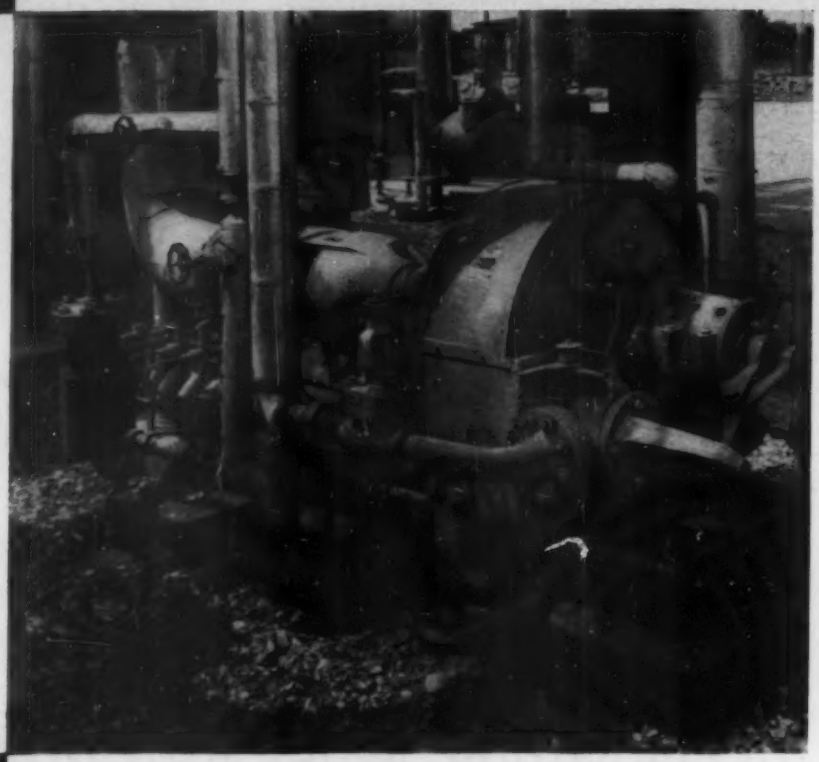

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ATOMICS

A section of POWER ENGINEERING covering current and forthcoming developments in the field of Nuclear Power throughout the world

ANDREW W. KRAMER
Editor

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PRESSURE SUPPRESSION CONTAINMENT

CONTAINMENT is an expensive but necessary precaution in the construction of nuclear reactor plants using water as a coolant or moderator, and designers have thought wistfully of how much better off we would be financially if containment could be dispensed with. Until recently there seemed very little hope of lessening the containment problem but, now, experiments carried on by Sargent & Lundy, consulting engineers of Chicago, point to a way of effecting a considerable reduction in containment costs by the use of what is called pressure suppression.

This principle is based on the fact that when escaping steam comes in contact with cold water or other heat absorbing material in a closed vessel, the pressure rise is much lower than if the water were not present. To test the effectiveness of this principle in the design of containment structures for nuclear reactors, Sargent & Lundy performed extensive tests last summer at the Hennepin Station of the Illinois Power Co. The equipment used consists of a vertical containment shell 14 ft in diameter and 32 ft high, designed for 100 psig. The shell was installed underground about 1200 ft away from the Hennepin power plant. A drum 42 in. in diameter and 23 ft long, designed originally for 700 psig, was placed inside the containment shell. This drum had a number of 12-in. openings along its vertical side closed by flanges, except for one opening in each test, which was covered by an explosion diaphragm designed so it would break at 600 psig. The test procedure was to fill the drum with 8000 lb ofwater, which was heated to boiling at a pressure of 600 psig by steam from the power plant, and then to rupture the diaphragm by means of a steam-operated triggering device. The bottom of the containment tank was filled with 17,000 lb of cold water.

When the boiling water in the inner tank was released in this manner, the energy release was equivalent to 500,000 kw of heat for the five seconds it lasted. Very much to the satisfaction of the engineers making the test, under these conditions the pressure rise in the containment was only 5 psig. Without the cold water, the theoretical pressure rise that was calculated was 153 psig. Thus, the presence of the cold water reduced the pressure rise from 153 psig to 5 psig.

The results of these tests certainly make the containment picture appear much brighter, since it will greatly reduce the cost. If this type of containment had been used by EBWR at Argonne, it would have reduced the over-all cost by $450,000 or about 10 per cent of the total EBWR plant cost. For a larger installation this number may be reduced to 5 per cent of the over-all plant cost which is, nevertheless, a substantial amount of money.

Andrew W. Kramer

The Physics of the GETR

New General Electric Test Reactor is unique in that the reflector is outside the pressure vessel. This permits bulky experimental equipment and instrumentation to be placed in regions of high flux without going inside the pressure vessel

By J. O. Arterburn, R. J. McWhorter, M. L. Weiss, and B. Wolfe
General Electric Co, Atomic Power Equipment Dept., San Jose, Calif.

FROM the point of view of accessibility to high neutron flux regions, a reactor of the swimming pool type has large advantages as compared to other types of research reactors. Unfortunately, at power levels in excess of about 5 Mw, cooling problems and pool water activation make the standard swimming pool design unacceptable. In order to achieve the high power density required to produce high neutron fluxes, previous reactor designs have utilized a large pressure vessel in which the core and experimental facilities were placed. Although this pressure vessel permits sufficient cooling for high power operation and isolates the active water, accessibility to high flux regions is considerably reduced and experiments must be tailored to operate in the limited confines of the pressure vessel. Examples of this type of reactor contained within a pressure vessel are the Materials Test Reactor (MTR) and the Engineering Test Reactor (ETR), located at the AEC Reactor Testing Station in Idaho.

Fig. 1 GETR Reactor assembly

The General Electric Test Reactor (GETR) is a 30-Mw light water moderated and cooled reactor designed to offer both the high flux advantages of the pressure vessel reactor together with the accessibility of a large volume of high flux space associated with the swimming pool design.

Design Considerations

Figure 1 shows the General Electric Test Reactor assembly. The reactor consists of a core contained in an aluminum pressure vessel and has the unique feature that the reflector is outside of the pressure vessel. The complete assembly of reactor core and pressure vessel is submerged in a pool of water. A cross-section of the reactor core is shown in Fig. 2, where it can be seen that the pressure vessel is placed as close to the core as possible, consistent with the use of square elements in a circular pressure vessel. By limiting the size of the core, considerable leakage from the core occurs and one finds the characteristic thermal flux peaking in the water reflector placed outside of the pressure vessel. This reflector region outside of the pressure vessel has a maximum unperturbed thermal flux in excess of 10^{14} nv (neutrons per sq cm per sec). There is considerable room in this accessible region for bulky experimental equipment, and instrumentation and equipment can be inserted and removed without opening the pressure vessel or resorting to complicated refueling machines. In addition to this high flux region in the water reflector external to the pressure vessel, there is contained inside the pressure vessel, within the reactor core, additional experimental facilities of the ETR type.

The design of the core has been determined primarily by the following ground rules:

(a) There should be three, 3-in. sq, through facilities.

(b) Control elements should be removed by at least one fuel element position from the three experimental through facilities.

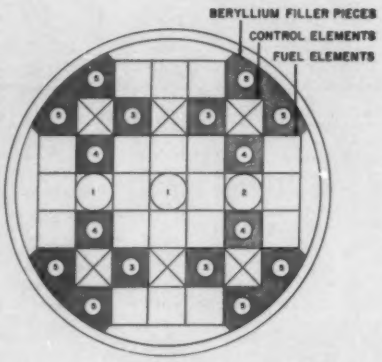

Fig. 2 GETR start-up core (30 Mw)
1—Al filler piece with al plug
2—Dummy Dresden test section (non-fuel)
3—40 per cent stainless steel plug
4—15 per cent stainless steel plug
5—Al plug

(c) There should be sufficient control to provide adequate safety and a convenient operating cycle.

(d) The through experiments should be in the highest flux regions possible and should be removed from each other by at least one fuel element.

These conditions, together with the decision to use control elements of the ETR type, dictated the core arrangement shown in Fig. 2.

In Fig. 2, it should be noted that there are a number of beryllium filler pieces which are interior to the core. They provide these advantages:

(a) They contain spaces for capsule experiments.

(b) They allow for adjustments in the core loading to compensate for the reactivity effects of changes in experiments. Thus, if the experiments are changed so as to increase the reactivity, the beryllium elements may be replaced with aluminum elements to compensate. This provision reduces (or eliminates) the necessity of ordering and storing fuel elements of various loadings.

(c) The beryllium filler pieces reduce the number of fuel elements required in the core and, thus, reduce fuel element fabrication cost.

The present GETR design, as out-

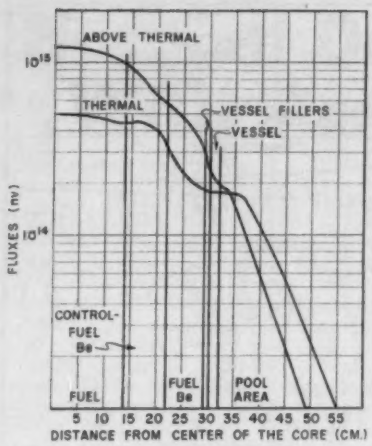

Fig. 3 Unperturbed Fluxes, Core at 30 Mw

lined above and presented in this article, utilizes a water reflector. There is no reason (except for expense) why part or all of the reflector region outside of the pressure vessel cannot be filled with carbon or beryllium as in the case of the Materials Test Reactor (MTR) reflector. Such reflectors would extend the high flux region in the reflector and measurably increase its volume;[1] studies have shown that the flux in some large-size experiments can be significantly increased by surrounding the experiment with graphite. Although such a reflector is not now contemplated for the GETR, one of the attractive features of this design is that such additions can be made at a later date with very little difficulty.

Reactor Characteristics

(a) NEUTRON FLUX. The flux levels in the GETR have been investigated under a variety of conditions.

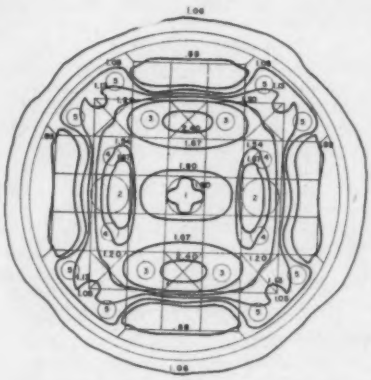

Fig. 4 Midplane Thermal Flux x 10^{-14}, Start-up core, 30 Mw

1—Al filler piece with al plug
2—Dummy Dresden test section (non-fuel)
3—40 per cent stainless steel plug
4—15 per cent stainless steel plug
5—Al plug

Figure 3 shows the thermal flux levels in the optimum case of an unperturbed reactor, defined as the reactor with experimental facilities loaded identically to that of the surrounding core or reflector. In this case, the maximum thermal flux level in the central experimental through facility is 5.2 x 10^{14} nv, while the maximum level in the other two through facilities is 4.7 x 10^{14} nv. The peak unperturbed level in the water reflector is 1.5 x 10^{14} nv.

The flux has also been studied under more realistic conditions. Figure 4 is a plot of the thermal flux in the GETR core as it has been loaded for initial operation. In the initial start-up core, all capsule positions are filled with dummy stainless steel or aluminum "filler plugs." These are designed so as to duplicate the effect of typical capsules so that the later removal of plugs and the introduction of capsules will produce very little nuclear effect. In the start-up core are a pressurized water loop in one of the off-center loop positions and dummy aluminum "filler pieces" in the other two loop positions. For economy of calculation, Fig. 4 assumes that there are two pressurized water loops; auxiliary calculations indicate that the replacement of the loop with a dummy filler piece produces only about ½ per cent decrease in reactivity. It can be seen that the experiments markedly affect the flux distribution. The results of a large number of calculations indicate that the thermal flux in the central loops will be about 2 x 10^{14} and about 1.5 x 10^{14} in the two off-center loops for typical water-moderated experiments. Typical non-moderated experiments (i.e. gas- or liquid-metal-cooled) will have typical fluxes 20 to 30 per cent lower. The thermal flux in the in-core capsules will be between 1 and 2 x 10^{14}. The thermal flux in the reflector region is very sensitive to the experiments considered. Small capsules will have fluxes of the order of 1 x 10^{14} nv. Typical loops in the reflector will attain fluxes of between 2 x 10^{13} and 8 x 10^{13} nv depending upon their composition and location.

Figure 5 is a plot showing the flux in a three-inch "boiling water loop" designed to measure the effects of radiation on water. Here, lead shielding has been placed between the pressure vessel and the loop to reduce the gamma-flux, since it was desired to hold a fixed ratio of neutron to gamma-flux. If neutron fluxes were the prime consideration, placement of the loop closer to the pressure vessel would increase the flux to 6 x 10^{13} nv. Figure 6 is a plot showing the thermal flux distribution expected in five gas-cooled loops presently being installed in the pool. (Incidentally, the flexibility of the reactor can be judged by noting that the gas-cooled loops were designed

[1] See, however, B. Wolfe—*Nucleonics*, November 1958, p 135.

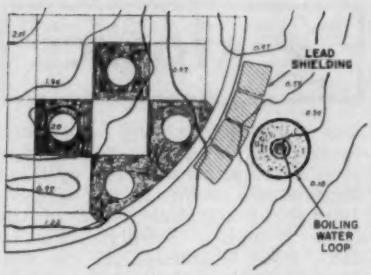

Fig. 5 GETR core with boiling water loop experiment. Midplane thermal flux x 10^{-14}

and installed after the reactor was built.)

(b) LOADING AND EXCESS REACTIVITY. The loading of the GETR will be greatly influenced by the characteristics of the experiments. For the case of the start-up core depicted in Fig. 4, the initial loading will be approximately 8.7 kg of U-235. This will provide an initial excess reactivity of k_{eff} of 11 per cent, divided as shown in the accompanying table.

Excess Reactivity at Start of Cycle (Per cent)

Temperature	0.5
Xenon (equilibrium)	3.0
Control	0.5
Available for burnup and buildup of fission products	7.0

The 7 per cent available for burnup and buildup of fission products other than xenon will permit operation of the reactor in excess of 24 days before refueling is required. This corresponds to burnup of 12 per cent of the initial 8-7 kg loading.

(c) GAMMA HEATING. When a material is placed in or near the core of a high power reactor, it is heated primarily by the absorption of gamma rays produced in the reactor. (In addition, of course, to its own fission heat if the material contains fuel.) The design of the reactor and of experimental facilities to be placed in the reactor must take into account the effect of this gamma heating. In particular, a high pressure loop must be designed for the large gamma heating which will occur as well as the high pressures in the loop. At the region of most intense gamma heating, the center of the core, heating will occur at the rate of approximately 20 watts per gram.

(d) VOID AND TEMPERATURE COEFFICIENTS; NEUTRON LIFETIME. Temperature coefficients of the GETR will be approximately 1 x 10^{-4} $\Delta k/k$ per degree centigrade rise.

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The void coefficient will be approximately 2×10^{-3} $\Delta k/k$ per percentage void in the moderator. The void and temperature coefficient are negative throughout the fuel region of the core, a highly desirable situation from a safety standpoint. The neutron lifetime in the reactor is approximately 5×10^{-5} sec. These values are, of course, affected by the contents of the experimental facilities, but change by less than 20 per cent for experimental loadings thus far contemplated.

(e) REACTOR CONTROL. Reactor control is accomplished by the use of six control rods controlling 0.18 Δk in reactivity. This control is divided into 0.11 Δk for reactor operation and 0.7 Δk for safety and shutdown. The control rods consist of two sections. The lower section contains fuel

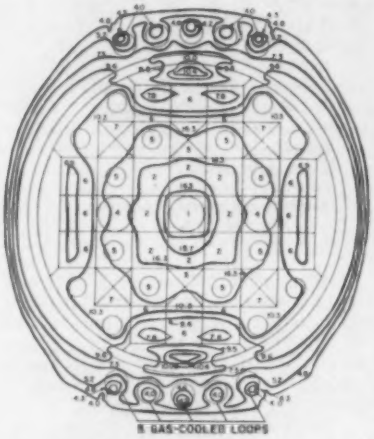

Fig. 6 Midplane thermal flux x 10^{-13}. Cycled core with ORNL helium-cooled loops, 30 Mw

1—Al filler piece and plug
2—Recycled fuel elements
3—Recycled fuel control
4—Pressurized water loop
5—15 per cent stainless steel plug
6—Fresh fuel elements
7—Fresh control fuel

and the upper section contains a black poison (boron stainless steel).

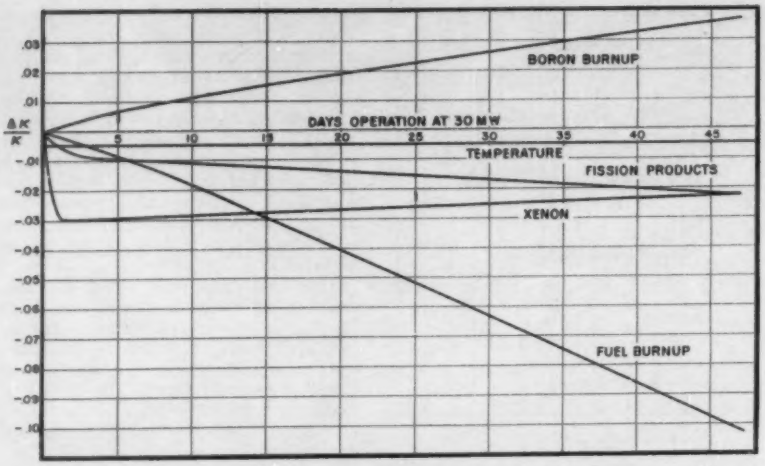

Fig. 7. Reactivity changes due to burnup. (Core with burnable poisons and experiments)

Scramming of the reactor is accomplished by dropping the rods so that the poison section falls into the core. One of the six control elements doubles as a regulating rod by having four inches of its travel servo-controlled. The four inches of travel corresponds to less than 0.7 per cent Δk at the most reactive position of the rod, and positive mechanical stops prevent motion of more than 4 inches by servo control.

(f) XENON. In all high flux reactors, the problem of xenon must be reckoned with. As indicated above, at equilibrium, the xenon concentration will cause approximately a 3 per cent decrease in reactivity. There is adequate control available to compensate for this equilibrium xenon. A more serious problem occurs, however, when there is a scram after the reactor has been operating at high power. In such an event, the xenon concentration increases after the scram at a rapid rate, and unless the reactor is restarted in a short interval after the scram, a restart becomes impossible until after the xenon has decayed (approximately two days) or unless the reactor is refueled. Experience at the MTR indicates that scrams due to the presence of experiments will not be uncommon. The results of a study of xenon override-time indicate that at the start of the cycle, there will be over 100 minutes available to find the cause of a scram and correct it before a restart is impossible. After about 21 days of operation a restart will not be possible.

(g) FUEL BURNUP AND BURNABLE POISONS. As noted previously, the initial excess reactivity of 11 per cent will permit operation for 24 full-power days. After this period half of the reactor fuel will be replaced. Thus, an individual fuel element will remain in the core for 48 full-power days, corresponding to burnup of approximately 24 per cent of its initial fuel.

The core described above does not utilize a burnable poison. After several cycles (24 days) of operation of the GETR, it is planned to utilize a burnable poison (boron) in the fuel elements. The utilization of the burnable poison will increase the possible running cycle from 24 to 48 days and will require an increase in fuel loading of 20 per cent. For the convenience of experimenters it is planned, even with the burnable poison, to operate on a 24-day running cycle; however, the burnable poison will materially reduce fuel costs. Figure 7 is a plot of the change of reactivity with time in the core utilizing the burnable poison. It can be seen that a cycle in excess of 48 days is possible. Again it is planned to refuel only part of the core at one time, leading to a fuel element lifetime of almost 100 full-power days, corresponding to a fuel burnup of approximately 36 per cent.

THE END

REPRINTS OF ATOMICS

Reprints of the ATOMICS sections from POWER ENGINEERING for the six months from July to December 1959 will be available about the middle of January 1960. Only enough of these will be printed, however, to take care of advance orders. They will be available at $1.00 per copy. If you want one of these reprints, please fill in the following form and send it to

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Hot Cell Doors Altered With Arcair Process

THE INGENUITY of the welding engineer of Partsco, Inc, a Columbus, Ohio firm, transformed a tough, expensive alterations task into a time- and money-saving assignment at one of the country's nuclear research installations. At the installation, two "hot cells" are used for remote study of radioactive materials. These are heavy-density concrete structures with walls two and three feet thick. Access is gained to each through large solid steel doors, which are lowered into the floor. The smaller cell has a door 12 in. thick, weighing 23,000 lb; the larger one a door 18 in. thick, weighing 42,000 lb.

To provide easier access to the inside of the hot cells, it was decided to make smaller access openings, about waist high, in the thick steel doors. By having these smaller openings in the hot cell doors, materials being studied for suitability for use in nuclear projects can be placed into or taken out of the hot cells without having to lower the entire door. Bids were let to local job shops to make the necessary alterations. Mr. Cecil Cline, the welding engineer for Partsco, Inc, decided that this job could best be done with an Arcair metal-removal torch instead of oxy-acetylene cutting apparatus upon which the other bidding job shops based their cost estimates. Mr. Cline, using an operator unfamiliar with Arcair equipment, cut a 10-in. diameter hole in the smaller steel door to a depth of 8 in. This was done by making repeated gouges, one over another, until the desired amount of metal was removed. This job provided a novel twist on the use of Arcair torches, which normally do not replace oxy-acetylene torches for cutting of thick sections of steel. On this job, however, it was impractical to cut the access hole desired with flame cutting devices, which along with being more difficult to control, would have required a lead hole being drilled through the entire thickness of each door. This drilling by mechanical means in itself would have been quite a feat.

After Mr. Cline's operator had gouged out metal to the depth of 8 in. and 10 in. in diameter, operations were started from the opposite side

Fig. 1 A new application for an existing tool is illustrated here. Arcair operator is using a heavy-duty model Arcair torch and ½-in. copperclad electrodes to cut a 10-in. diameter access hole through a 12-in. thick solid steel door

Fig. 2 From the reverse side, an oxy-acetylene torch was used to cut a center opening. Flame cutting torch removed larger amounts of metal for initial cut. Finish work on the doors of the hot cells was done with Arcair torch

Fig. 3 Removing slag from access door in hot cell produced by oxy-acetylene cutting from opposite side. Finish work was then done with an Arcair torch to complete the 10-in. diameter opening through the 12-in. thick solid steel door

Fig. 4 A stepped steel sleeve was then tack-welded in place and packed with lead-wool to complete seal against radiation from interior of the hot cell. Right-angled step in the steel sleeve prevents the radioactive radiation from passing when plug is in place

Fig. 5 With access door opening in 12-in. thick steel door completed, operator prepares to place 240-lb metal plug in position. Note the protective clothing worn by the operator when working in the hot cell to protect him against the dangerous radiation

Fig. 6 This photograph shows the 12-in. thick steel door lowered to place the access door plug in position. Here again, the operator had to wear protective clothing to protect against radiation. Caps, boots, and gloves had to be destroyed after use

of the hot cell door. Several pieces of metal were cut from the center of the access opening with a flame cutting torch. The oxy-acetylene cutting torch removed several large chunks of metal from the center faster than could have been done with the Arcair gouging torch. With the center removed, more accurate finishing cuts were made with the Arcair torch. The technique here was to "shave" away unwanted metal by making repeated gouges in a circular direction. This method permitted accurate control of the amount of metal removed, more so than could have been had using other equipment. Operators became adept at shaving out the metal

The air blast from an Arcair torch blows the metal melted by the arc away from the worked surface; therefore, it was necessary on this job to equip the operator with special protective clothing. During the initial gouging the melted metal was thrown back toward the operator, until a hole was cut through the steel doors. The operator was equipped with an asbestos apron, asbestos gloves and asbestos sleeves, and when working in the hot cell, other protective clothing was worn to avoid radioactive contamination.

After the 10-in. diameter cuts were completed in the two hot cell doors, steel sleeves were fitted into place and tack-welded. Lead-wool was then packed between the sleeve and the opening in the door to complete the seal. The sleeve is of a stepped design, which will prevent the escape of radiation when the access plugs are placed into position. Because the radiation can travel only in a straight line, the 90 degree offset of the sleeve stops their travel into the outer chamber. After the sleeves were welded into place, the matching metal plugs of the same length as the door thickness were placed into position.

The entire job was completed in less than one week's time. Actual work time with the Arcair torch was far less than 25 hrs, even though the torch operator was unfamiliar with the equipment when the job was begun. It is estimated that much better time could be made on a similar job, now that the rudiments of the best technique are down pat. Needless to say, the research facility benefited from a work time standpoint and from the lower cost involved than what would have resulted from using other work methods. THE END

Guaranteed-Price Atomic Power Offered by Westinghouse

AS PART OF its activity in atomic power, Westinghouse is continuously analyzing the field on nuclear power reactors to evaluate the status and potential of the many different types. As a result of recent evaluations, this firm, in September, boldly announced its offer to build nuclear power plants at guaranteed cost. As expressed by officials of both the Atomic Power Department and the Electric Utility Engineering Department, Westinghouse will "guarantee the manufacturers' controllable costs: plant capital cost, plant capability, and fuel burnup. Having guaranteed these, the cost of energy to the utility is directly a function of: plant load factor, individual annual charges, and operation and maintenance costs — all of which a utility can control."

Westinghouse feels that there are three atomic power plant types that utilities should take into their nuclear power programs. In promoting these plants Westinghouse feels that the distinction between pressurized-water plants and boiling-water plants will disappear as sizes and pressures go up. As a consequence the company has abandoned the terms *pressurized* and *boiling*, and from now on will offer both types of reactors, as "closed-cycle" and "direct-cycle" respectively.

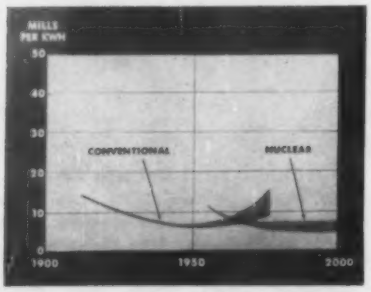

Fig. 1 Comparative Power Costs

The three specific plants Westinghouse is offering to the utilities are (1) The Combination Plant, (2) The Integral Boiling and Superheat Reactor and, (3) The 330-Mw Closed-Cycle Plant.

In their analysis of nuclear power costs and conventional power costs, Westinghouse is of the opinion that nuclear power costs will come down in the years to come, while conventional power costs will rise. Figure 1 is a chart showing power costs in mills per kilowatt hour from 1900, together with a prediction of power costs for both conventional and nuclear power plants. It will be seen that these curves are going to cross in the near future; where and when is a matter of individual utility economics and progress of the art. This means that utilities must now consider where, and when, and how much to invest in their nuclear future if they are going to continue to produce economical electric power.

Although various reactor concepts have been investigated and are still under close study to determine their technical and economic feasibility, it has become clear that, intriguing as some of these concepts are in their promise for superior economics, many of them will require considerable further development before they can be fitted into the commercial nuclear power program. For the immediate future, in this country at least, the water-cooled and water-moderated reactors seem to offer the best chance of achieving competitive power. It also is the class with which we have had the most practical experience. Among the water-cooled reactors, the first to be developed was the pressurized-water reactor, used on the *S.S. Nautilus* and at Shippingport Station. The pressurized system is shown in Fig. 2. In this system, water under pressure circulates through a primary loop, picking up heat in the reactor and giving it up in a heat exchanger to a secondary system that generates steam. This system has a wide range of application — from 1 to 400 Mw (electrical). As will be shown, Westinghouse makes a recommendation that will help to realize the full potential of this concept and bring it to the point of competing with fossil fuels on a mills per kwh basis.

The second major division of the natural water systems is what Westinghouse calls the direct-cycle type, where steam generated in the reactor is piped directly to the turbine. In one such reactor, called the direct-cycle, natural-circulation system, the incoming water passes through the reactor core, forming a steam-water emulsion. Steam-water separation is effected inside the reactor. This system has excellent application in the small power ranges. However, because of the water flow characteristics and steam separation problems, it takes a large core to produce sufficient heat.

To overcome this difficulty, forced circulation of the water can be used. This brings about higher nuclear efficiency and increases the hydraulic stability of the reactor. Capital costs are increased, of course, but the range is pushed to about 150 Mw. In this

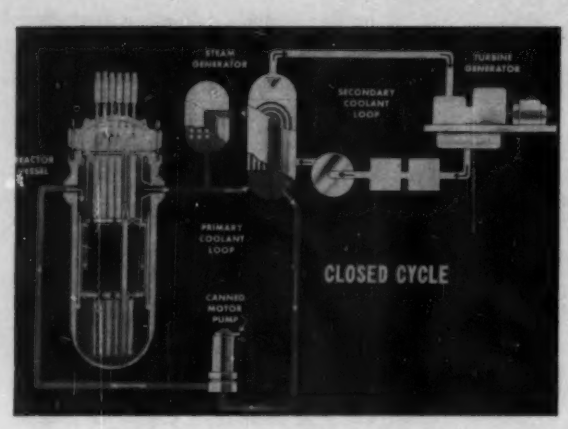

Fig. 2. The closed-cycle reactor system

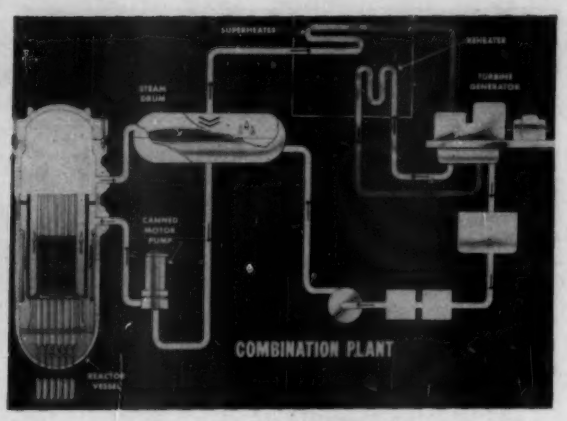

Fig. 3. The Combination plant

size plant, the forced-circulation system has excellent prospects.

The combination of the direct-cycle and closed-cycle system is known as the dual cycle. In this case the steam generated directly in the reactor goes to the high pressure end of the turbine, while the lower pressure steam produced in the secondary system of the closed cycle goes to a low pressure stage of the turbine. The power range of the dual cycle plant is from 150 to 300 or 400 Mw. This system has higher power density than the other two but also higher capital costs.

For the larger plants it is important to determine which of these two systems has the greater present and long-range potential. To establish this comparison, Westinghouse has made a number of parallel technical and economic studies for Closed-Cycle and Dual-Cycle plants up to 300 Mw. The power costs for the Closed-Cycle and Dual-Cycle plants are essentially identical over the range of applicability. The saving in heat exchanger capacity for the Dual-Cycle plant is almost offset by the reduction in piping and other components for the Closed-Cycle plant.

From a thermal efficiency standpoint, the water reactors can be greatly improved if superheat is added to the steam to bring it up to modern turbine conditions. Heat rate reductions of 30 to 35 per cent can be obtained by the use of high pressure superheat-reheat cycles. Superheating is the next big step and it is a significant part of several specific recommendations made to the utilities.

As a result of the studies made by Westinghouse a detailed rundown on the three water reactor plants that hold the most immediate promise for the electric utilities is given as follows.

Combination Plant. The first plant is called the combination plant, because it uses both nuclear and fossil fuel. It meets the present need of utilities for an economical way of investing in the nuclear power future. The turbine, rated at 225 gross Mw, can essentially be ordered from the catalogues. Steam-inlet conditions at the first stage are 1800 psi at 1000 F, with reheat temperatures of 1000 F. These steam conditions can be achieved by using a direct cycle. The next step is superheating to 1000 F. A superheater using nuclear fuel could be designed for this purpose, but this second reactor would present a whole new set of problems and would be prohibitive economically. The most realistic and available solution is to use a fossil-fuel-fired superheater. In addition to superheating steam before it goes to the first stage of the turbine, the superheater is used to reheat steam to 1000 F, after it passes through the first section, and before it is fed back into the second section of the turbine.

Figure 3 shows the general operating principle and main components of the combination of the combination plant. In the core of the reactor, water circulates and boils at 2115 psi, dry and saturated. Canned motor pumps circulate the water through the core. A steam-separating drum between the reactor and the superheater separates water from the steam and insures that only steam is passed on to the superheater. The water collected at the separating drum is returned to the reactor cycle. The superheater, which can be fueled with either oil, gas, or coal, is 76 x 65 ft in rectangular dimension and stands 146 ft high. The nuclear portion of the plant contributes about 300 Mw (thermal) and the superheater about 220 Mw (thermal) to the net power output of the plant. Together, they would produce an electrical output of 225 Mw. The total heat rate of this plant would be the best yet obtained from a nuclear plant — 9040 Btu's per kwh, net.

Work toward construction of this plant can be started immediately and it would present few problems. As to economics — the real reason for recommending the construction of such large plants is that the direct-cycle nuclear power plant with fossil-fuel-fired superheat and reheat will produce electric power for 7.3 mills per kwh. This cost breaks down as follows: 3.4 mills in capital investment; 2.7 mills for fuel; 0.5 mills for indirect costs, and 0.7 mills for operation and maintenance. The 2.7 mills fuel figure is based on current costs and using 30¢ per million Btu oil in the superheater. Coal might cost less than oil in itself, but the attendant capital investment in rails, storage, ash disposal, etc, would bring the actual cost to about the same figure.

It is important to note that fossil fuel costs affect the total power cost estimates of the combination plant. At 40¢ per million Btu, power costs on the combination plant will rise to 7.7 mills per kwh; at 60¢ to 8.6 mills per kwh. This may seem at first to be a disadvantage, but compare it to the estimates of a rise in power costs on a completely fossil-fuel-fired plant. At 40¢ per million Btu, the average power cost is 7.4 mills; but at a fossil fuel cost of 60¢, power cost is 9.2 mills.

Today, the all fossil-fuel power plant holds the economy edge over the nuclear plant in all but the highest fuel cost areas. In some areas the combination plant will win out on a mills per kwh basis *over the lifetime of the plant.* Thus, there is definitely a place for the combination plant until the all nuclear plant supplies the least costly source of power in every area.

Integral boiling and superheat reactor. The plant is shown in Fig. 4. Here water is boiled and then superheated in the same reactor core. This plant is further in the future than the combination plant; Westinghouse envisages a full-scale plant of this type to be operating in 1975, if the proper steps are now taken towards its development.

In this reactor a number of pressure tubes are inserted into the center and around the periphery of the center of the reactor, which is essentially a large block of graphite. This is the moderator. Smaller rods holding the nuclear fuel are inserted into the pressure tubes, and between these small fuel rods there is enough room for the coolant water to flow. In op-

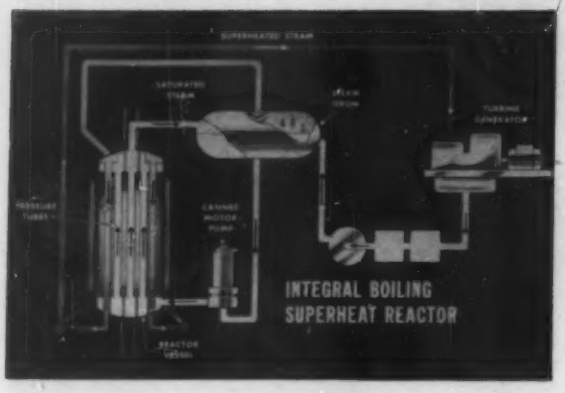

Fig. 4 Integral boiling superheat reactor

eration, the water is boiled in these tubes and the steam passes upward to four steam drums located above the reactor. The separated water is returned to the bottom of the boiling tubes in the center region of the reactor. The separated steam flows into the upper end of the superheating tubes located in the perimeter area of the core, downward to the superheater header, and then on to the turbine.

Within the carbon-steel containment vessel, and completely blanketing the graphite moderator, is helium under 100 psi. The helium will control the heat transfer from the graphite moderator to the pressure tubes, at the same time maintaining the graphite temperature within safe operational limits.

The integral boiler and superheater reactor, although a long step in the future, is ultimately a very economical, very efficient 200-Mw reactor. A thorough research and development program coupled with construction of a prototype must precede the full-scale 200-Mw plant. To solve the problems involved in the construction of this type plant, Westinghouse recommends immediate consideration by utilities of the prototype plant — just 1/10 the size of the final plant, 20 Mw. Naturally, no prototype plant can be economically competitive, but the utility that builds it will be making a real contribution because this concept promises good economy in the more distant future.

330-Mw Closed-Cyle Plant. All this discussion about the long range all nuclear plant does not mean that a large, economical all nuclear plant cannot be built for utilities today.

Westinghouse is at present recommending the construction of a 330-Mw closed-cycle, water-moderated plant. The philosophy behind this plant is based on the facts that (a) there is economy in large reactors, and (b) the closed-cycle plant is the most proved type to date. This recommendation is the result of a detailed study to establish feasibility and economies of both cycle plants up to 400 Mw, with plant startup to be early 1965.

The closed cycle, as described earlier, is that shown in Fig. 2. The fuel is in the form of uranium oxide pellets, clad in either stainless steel or zircaloy. For more uniform heating and better fuel economy, Westinghouse has developed a novel method of loading the core in three levels of enrichment, arranged in three concentric circles. Fuel life for this reactor is three full-power cycles. After each cycle the center of the fuel is removed. Then the second and third layers of fuel are moved towards the center, and a new outer layer added. The uniform heat rate that will result this way will allow the use of fewer control rods, less expensive fuel, and more kilowatts from a given fuel load — all of which means definite economy.

After the primary loop water passes through the reactor, it flows to one of the five steam generators. The flow of water through the reactor is 75 million pounds per hour. Each of the steam generators produces approximately 900,000 pounds per hour of dry and saturated steam. All five funnel through a common header into the secondary loop, which feeds steam to the turbine at a rate of nearly 4½ million pounds per hour.

This 330-Mw plant is based on studies of the closed-cycle plant at every rating from 5 to 400 Mw. In these studies it was found that power costs reduced sharply in the closed-cycle plant until 330 Mw is reached. Then there is a sharp leveling in the curve. This leveling reflects an added capital expenditure needed above 330 Mw. At that point, the largest single-shaft, 1800-rpm turbine is being used, and beyond this point, parallel turbines are necessary.

Further, the economics of the 330-Mw turbine are very attractive. It is a highly efficient, 1800-rpm, tandem-compound turbine, with both a high pressure and low pressure unit.

Since the technology behind the closed-cycle reactor is far advanced, no serious technical problems are foreseen in extending the size of the reactor to match this turbine.

This plant, according to Westinghouse engineers, is the first all nuclear power plant to produce electric power on a reasonably competitive mills per kwh basis. Here are the figures — using the same ground rules as in the case of the other concepts; for capital expenditure, 3.3 mills per kwh; fuel, 3.0 mills per kwh; operation and maintenance, 0.5 mills per kwh. Including indirect costs of 0.5 mills per kwh, the total cost per kwh: *7.3 mills.*

Summary

This completes the detailed analysis on the three water reactors Westinghouse engineers think are ready for consideration by utilities *now*. As discussed earlier, the integral boiling and superheating reactor is farther away in time than the other plants, and the first one to be built would be a 20-Mw prototype plant. Research and development cost is the big item; according to Westinghouse calculations this will be 11.3 million. Capital cost of the prototype plant itself is estimated at 17 million — a total cost of some 28 million dollars.

The 225-Mw combination plant can be built essentially from today's technical know-how. Research and development is estimated at 4.5 million, and the plant itself will cost $45 million.

The third recommended plant is the 330-Mw closed-cycle plant. Again because of its proved design, a relatively low cost research and development cost of 4.4 million dollars is required. The plant itself will cost $68 million. Today's most economical plants, at an estimated 7.3 mills per kwh, are the 330-Mw and the combination plant.

In the long range, Westinghouse will guarantee the manufacturers' controllable costs: plant capital cost; plant capability; and fuel burnup. Having these guaranteed, the cost of energy to the utility is directly a function of plant load factor, individual annual charges, and operation and maintenance costs — all of which the utility can control. THE END

Criteria for Ocean Disposal

The National Academy of Sciences–National Research Council panel, which recently recommended 28 sites between Boston, Mass. and Corpus Christi, Texas, for off-shore disposal of packaged low-level radioactive wastes, has announced the following criteria for safe disposal of these wastes: survey of water circulation and inventory of bottom-living organisms; limitation of wastes to 250 curies per year and 100 curies per month of Sr^{90} or its equivalent, per site; separation of adjacent disposal areas by at least 75 miles and limitation to three areas in any 300-mile coastline; use of sinkable containers; and periodic monitoring. Limitations were based on potential return of radioactive wastes to man by ingestion of contaminated marine food products.

ATOMICS

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Garnett, Kansas Light Plant in 1938, selected Standard Oil diesel lubricant

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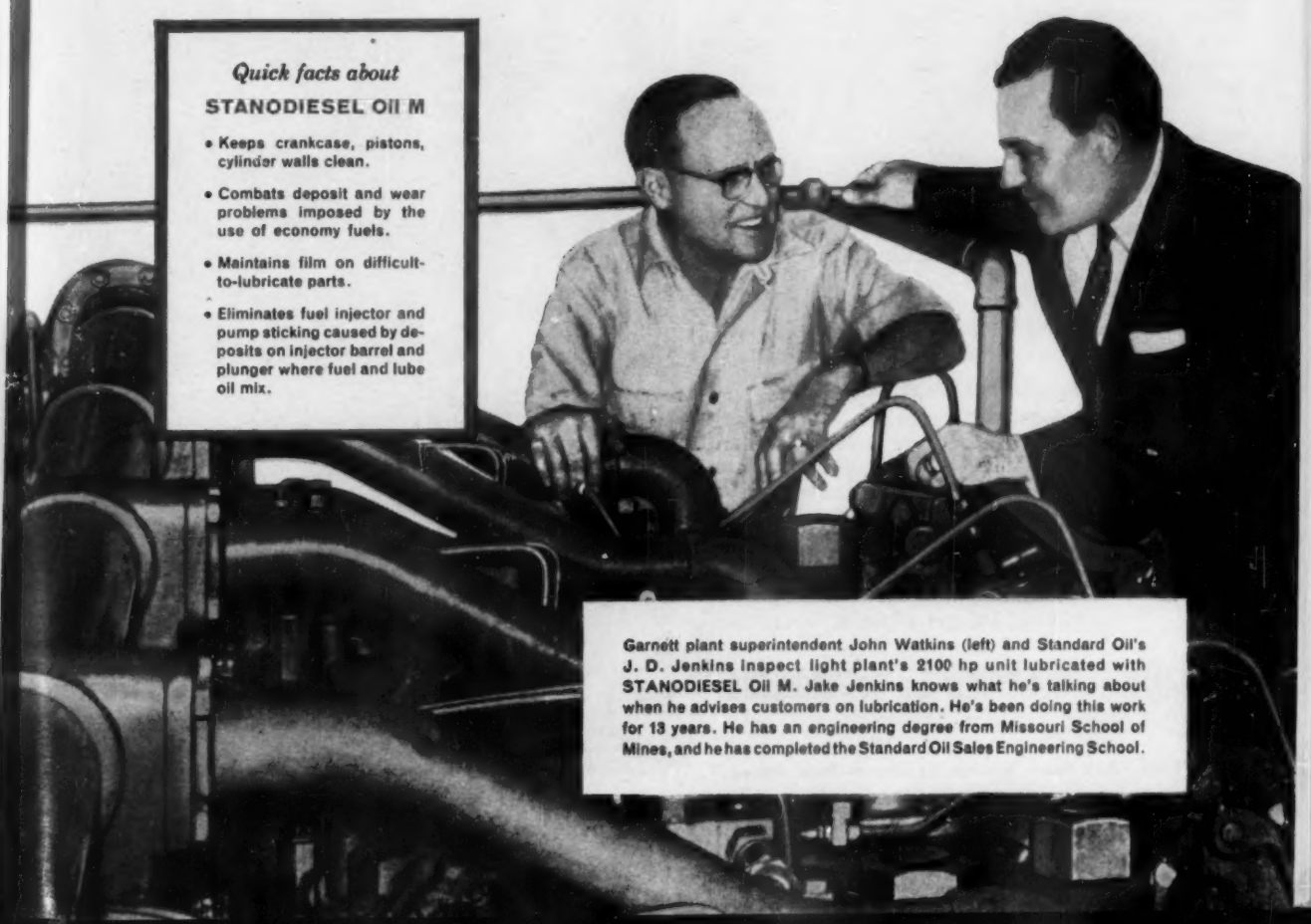

Garnett plant superintendent John Watkins (left) and Standard Oil's J. D. Jenkins inspect light plant's 2100 hp unit lubricated with STANODIESEL Oil M. Jake Jenkins knows what he's talking about when he advises customers on lubrication. He's been doing this work for 13 years. He has an engineering degree from Missouri School of Mines, and he has completed the Standard Oil Sales Engineering School.

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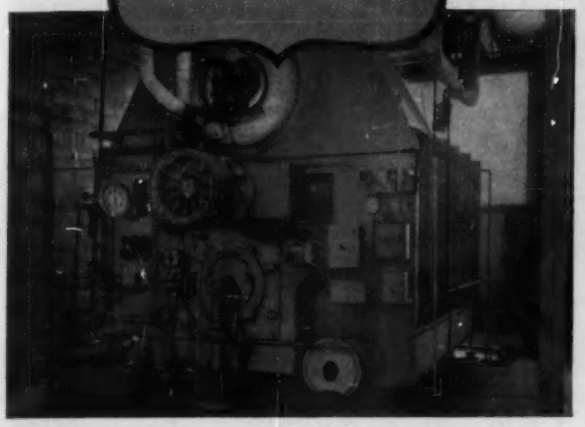

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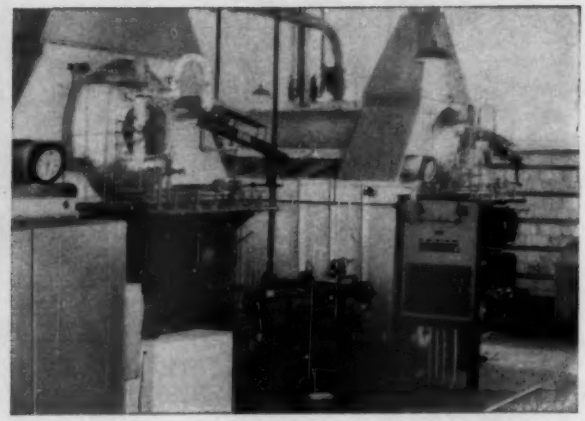

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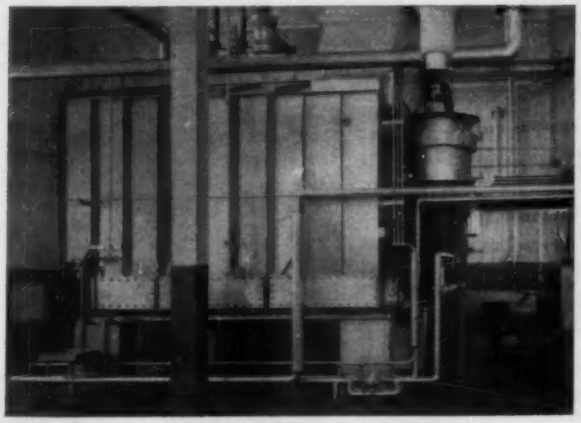

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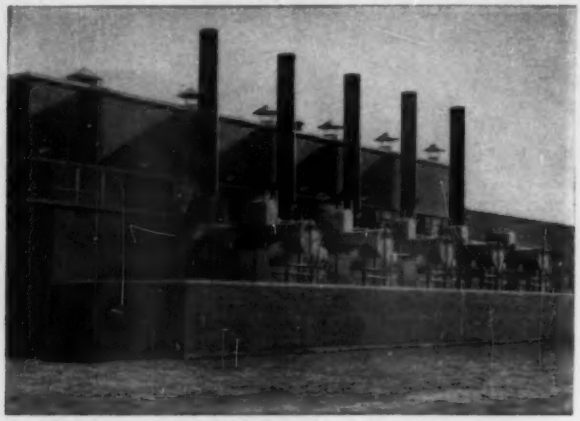

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8 Preheat-Postheat Before, After Welding
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices

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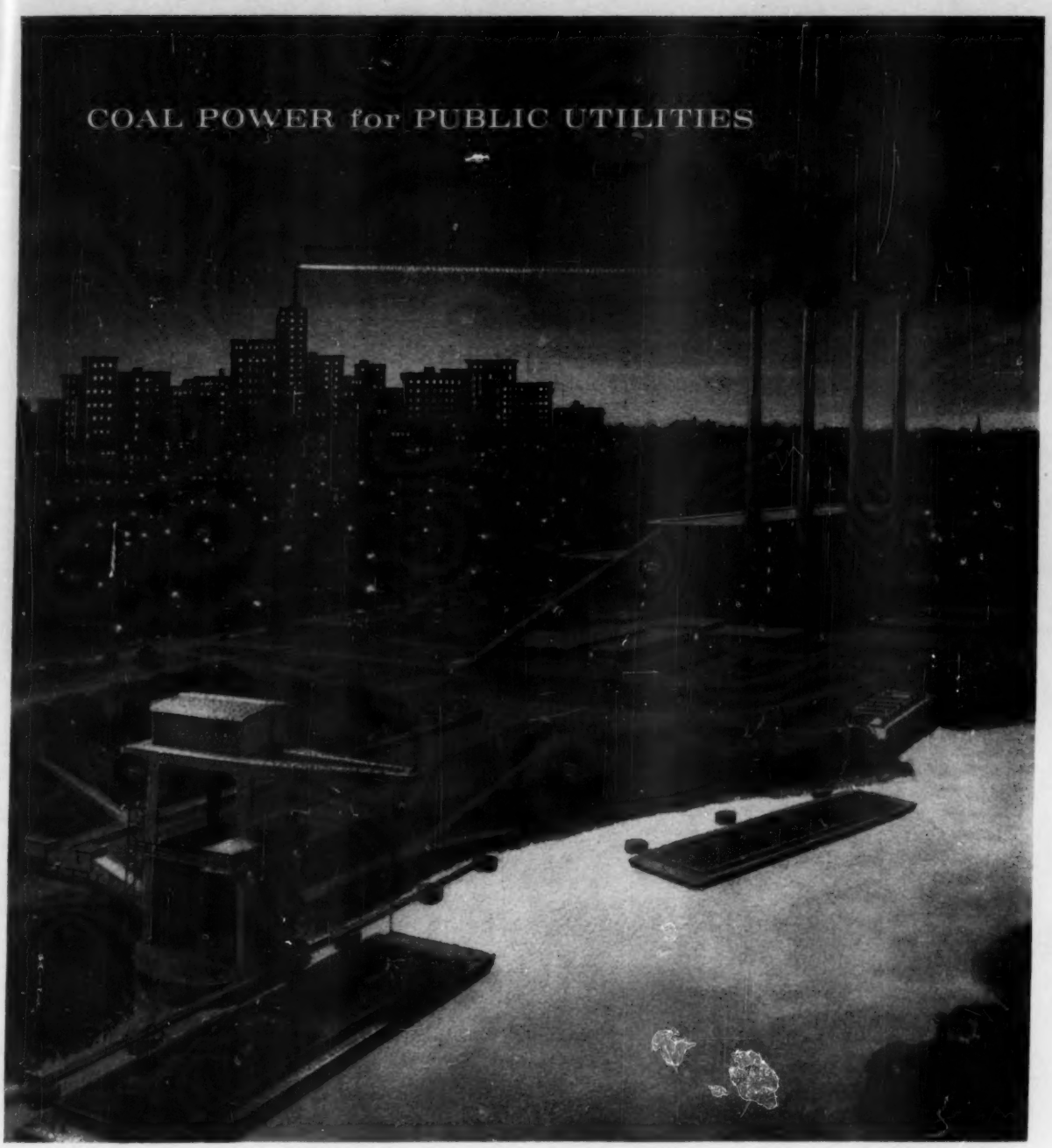

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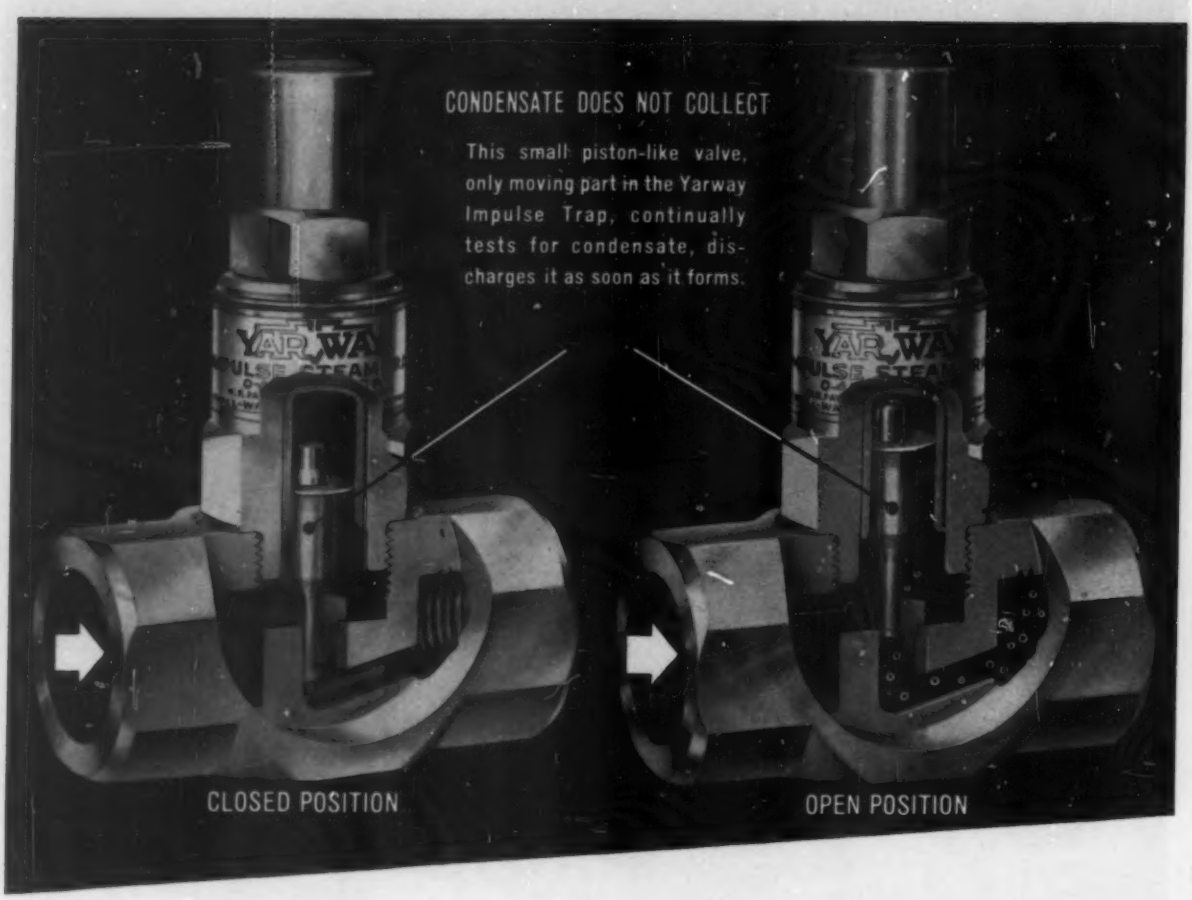
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TRACERS

Power Engineering's Monthly Probe of Power Facts

BullDog Electric of I-T-E Circuit Breaker Co is out with a new bus distribution duct system. Called "XL" Duct, it has at least three newsworthy features: lowest voltage-drop yet offered, great labor savings in installation and relocation, supports necessary only at every 10 ft. For a complete account, watch for an early issue of POWER ENGINEERING.

Geothermal steam is on the verge of becoming a practical source of power in California. Location is near the resort area community, The Geysers. Pacific Gas & Electric Co is building a pilot power plant which will utilize steam collected from wells extending 800 ft into the earth. Steam at 348 F and under 100 psi or more will be sent directly into the plant's turbines.

Important new development is Inco CEM, or composite electrolytic materials used as coatings which give extremely high corrosion-resistance and wear-resistance. These include materials such as carbides or aluminum particles of 15 to 35 per cent suspended in a matrix. In general the CEM may be used on any metal that can be electroplated. Ductility is claimed to be in the order of 10 to 1 better than chromium. although it is stated that lubrication effect is not as good.

Instead of using a seal well to maintain and control siphonage of condenser circulating cooling water, the new George F. Weaton steam power plant at Monaca, Penna, has installed a butterfly valve at the pump house on the outfall line. This means more operating economy, because the operator can take advantage of the maximum siphon regain at any condition of flow. See W. B. Ball's article in this issue, page 73.

As reported in the ATOMICS section in this issue, Westinghouse has attained a degree of confidence in its ability to design nuclear power plants sufficient to stake its reputation in offering to guarantee the price of nuclear power. In two types of atomic power plants which the firm is ready to build at once, it is offering the utility companies a guaranteed power cost of 7.3 mills per kwh, net electrical output. This cost includes all manufacturer's controllable costs: plant capital cost, plant capability, and fuel burnup.

Research and testing by Bituminous Coal Research show that stack spray collection efficiency is a function of the waterflow through the nozzle, and that maximum efficiency is obtained by the use of 0.4 gal per minute per sq ft of stack area. For anyone interested in stack spraying as a means to reduce stack emission, bulletin BCR Aid to Industry 500–330 explains location of the spray, correct nozzle size and pipe diameter, proper water pressure and other details.

Can fuel cells be thought of as really practical? Allis-Chalmers staged a dramatic answer to this perennial question in a test involving a tractor at work, powered by a bank of 1008 cells. Read all about it in our report on page 85 of this issue.

Making Quality Pipe Welds Today

Increasingly critical requirements of steam and atomic power plants are demanding greater fabrication and welding quality and more sensitive inspecting techniques. Considerable progress is being made toward increased requirements without reducing operating safety

By HELMUT THIELSCH*

INERT-GAS tungsten-arc welding of the root pass in piping was first done about 10 years ago to eliminate the use of backing rings. As with any new process, the initial welding techniques produced new problems due to cracking in the root pass (see How Sound Are Inert-Gas Tungsten-Arc Root-Pass Pipe Welds?, POWER ENGINEERING, April, 1956).

In fixed-position pipe welds, concavity on the lower half of the pipe joint, Fig. 1, due to sink of the weld metal was also generally considered objectionable. These problems have been overcome with consumable insert rings located eccentric to the centerline of the pipe.

As illustrated by the top and bottom views in Fig. 2, the sag of the molten metal is counteracted by locating the rings above the "land" of the pipe joint. The resulting convexity of the root weld deposit provides greatest assurance of weld soundness, as illustrated in Fig. 3.

Inert-gas tungsten-arc welding of carbon steel piping generally resulted in "bubbling" and porosity formation, as illustrated in Fig. 4. The primary cause is insufficient deoxidation in the base metal, even in so-called fully deoxidized pipe steel classification as ASTM A106. By providing carbon steel insert rings with sufficient additional deoxidizer, sound root-pass welds, Fig. 5, can now easily be made in carbon steel piping. A desirable composition of the insert ring, for example, is:

C	Mn	Si	P	S
0.13	0.92	0.51	0.010	0.021

During the root-pass welding operation the deoxidizer is fluxed out, so that the weld deposit has the proper composition corresponding to that of the base metal. As a result of these developments, carbon steel piping is now extensively welded by inert-gas tungsten-arc root-pass welding with the "modified" carbon steel insert rings.

For example, a number of shipyards have now eliminated all backing rings in their power plant and other pipe butt welds. These welds, made by inert-gas tungsten-arc root-pass welding with the modified insert rings, are significantly lower in cost since they eliminate the cost of backing rings. Moreover, they help to eliminate weld defects such as lack of penetration, excessive porosity or slag inclusions and sink, which reduces considerably the over-all cost of welding by eliminating weld repairs.

*Metallurgical Engineer, Grinnell Co, Inc, Providence, Rhode Island

Why This Article

Pipe welding, until recent years considered an art, is now a technology. Several new developments, as described here, have contributed to this changed status. These new techniques, providing better control over the welding operation, give greater assurance of the quality of the completed welds.

Induction Heating Fixtures

Under the ASA code for pressure piping and the ASME boiler and pressure vessel code section I and case 1181-2, it is necessary to stress relieve carbon steel piping in wall thicknesses of ¾-in. and over and chromium-molybdenum alloy steel piping in diameters of over 4-in. OD, regardless of wall thickness.

In field welding of power plant piping the required stress relieving is normally done by induction heating at 60-cycle or higher frequencies. On the heavy wall pipe now used in power plants, a 60-cycle frequency is more efficient and permits greater uniformity of heating than higher frequencies which tend to heat more the surface of the pipe.

Induction heating is normally accomplished by "wrapping" a conductor around the pipe joint to be stress relieved and passing a current of about 700 to 1500 amp through the conductor. Best results are obtained with water-cooled conductors since heating of conductors reduces the life and increases resistance to current flow, thus lowering the efficiency of induction heating.

In the past, copper tubing ⅜-in. OD by 0.050-in. wall was normally used as conductor. However, bending the tubing around the pipe required two to three men and was a cumber-

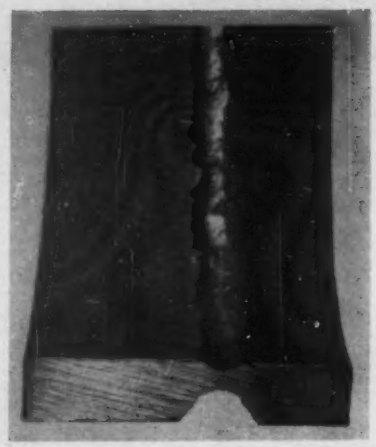

Fig. 1. Problem of concavity on lower half of joint, from inert-gas tungsten-arc root-pass weld, has been solved

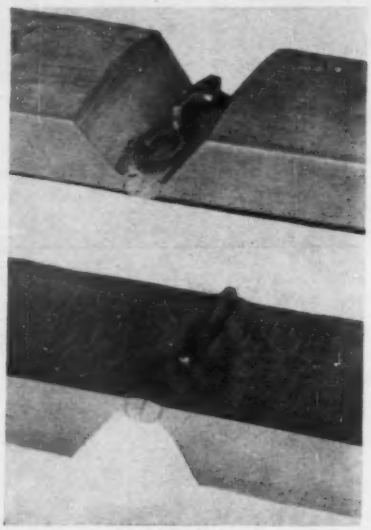

Fig. 2. Locating the rings abeve "land" of the pipe joint solves concavity

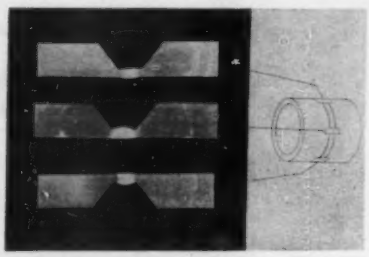

Fig. 3. Cross section of a weld using insert rings eccentric to the centerline

Fig. 4. "Bubbles" in inert-gas tungsten-arc weld in carbon steel piping

Fig. 5. Sound root-pass weld deposit in carbon steel made by inert-gas weld

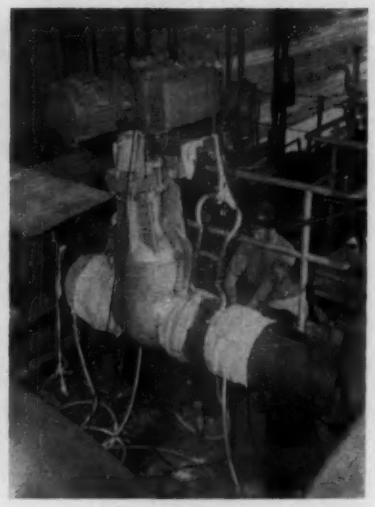

Fig. 6. "Wrapping" flexible tubing around joint prior to stress relieving

some operation since the copper tubing work hardened progressively. After being used approximately five times, the tubing had to be softened again by annealing.

By means of flexible tubing, Fig. 6, the wrapping time has been considerably reduced. Moreover, subsequent annealing is no longer required. One disadvantage of flexible tubing is that it burns out or wears out more readily than does copper tubing; nevertheless, it is the more economical method when considering the relative high cost of labor.

To provide for faster assembly, better heating efficiency, Snap-On induction heating coils have now been developed, Fig. 7. By means of a flexible link these coils can be readily slipped over pipe, removed or shifted, thus eliminating the time-consuming winding or bending of the flexible coils or copper tubing. The electric circuit in the Snap-On coils is closed with water-cooled copper knife blades pulled together by means of luggage link-type lever mechanism forcing together the knife blades with tight contact which cannot be opened manually. Weld joints adjacent to valves, where the ends leave insufficient room for standard width Snap-On coils, can be stress relieved by means of three-layer coils, Fig. 8.

Rapid Heating Rates

Since heating of the pipe at a 60-cycle frequency is uniform across the wall thickness, so that transverse stresses causing possible upsetting are not produced, rapid heating rates are permissible. This is particularly desirable in the annealing of weld deposits in austenitic stainless steel piping. The pipe weld area is heated as rapidly as possible to 1950 F, after which the Snap-On coil is quickly removed to permit water quenching of the weld area as rapidly as possible. Typical heating rates are shown in Fig. 12.

In welding the root pass on stainless steel piping by the inert-gas tungsten-arc welding process a heavy cauliflower type of scale forms on the underside of the weld, Fig. 9. In the majority of applications this heavy scaling is extremely undesirable. By displacing the air underneath the joint with either an inert-gas or nitrogen, a process referred to as "purging," smooth scale-free weld surfaces are produced, Fig. 10.

Purging is normally done either with inflatable balloons or with so-called "purging fixtures." Although both methods have advantages and may both have to be used, the purg-

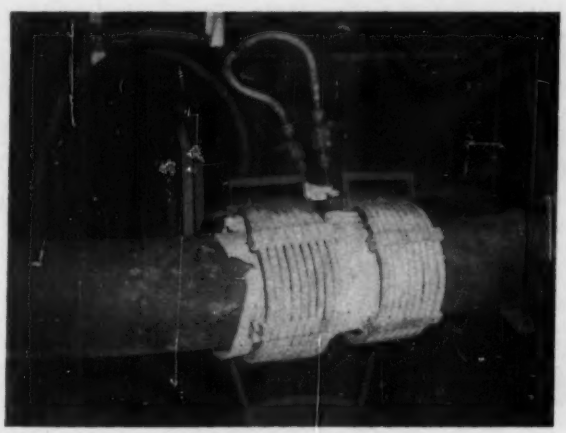

Fig. 7. Snap-On induction coil around pipe butt joint for stress relieving during erection of pipe in power plant

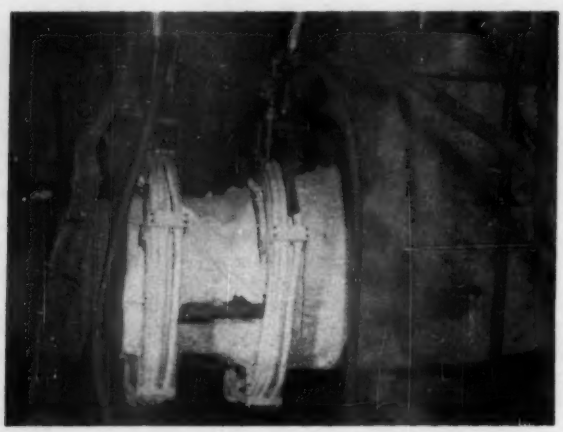

Fig. 8. Three-layer Snap-On coil for stress relieving welds which are adjacent to valve during erection in the plant

Fig. 9. Heavily oxidized "cauliflower" scale on underside of steel pipe weld

Fig. 10. Scale-free underside of stainless steel weld purged with inert gas

Fig. 11. Hot-radiography fixture for butt welds at interpass temp to 600 F

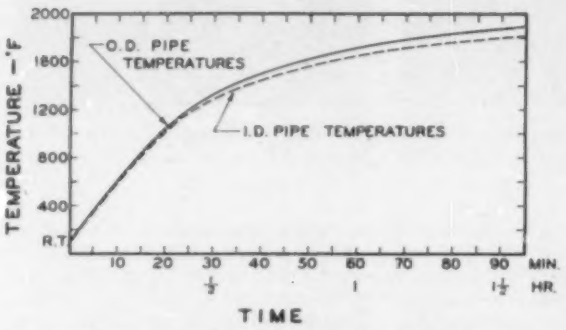

Fig. 12. Chart showing heating rate to 1950 F and uniformity obtained with three-layer Snap-On induction heating coil

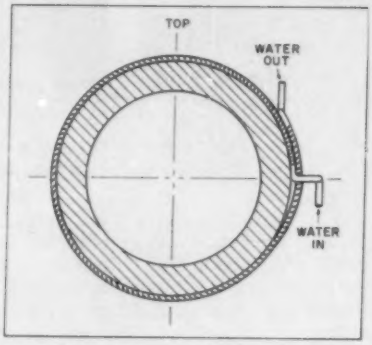

Fig. 13. Sketch of hot-radiography fixture which keeps film temp below 120 F

ing fixtures require less gas for the protection against oxidation of the weld joint, since they can be placed closer to the weld joint.

Hot Radiography

The majority of weld failures in pipe butt joints originate with a defect or notch at the ID of the pipe. Because of increasingly severe service environments, engineers are becoming more concerned with the soundness of the root weld deposit. Since radiography of the completed pipe weld may not reveal critical defects such as root cracks (see above reference), radiographic inspection of the pipe butt joint after the first or one or two subsequent weld passes is highly desirable.

On carbon steel and stainless steel pipe butt joints it would be permissible to cool the weld area to room temperature after one or several weld passes have been made. On chromium-molybdenum piping, however, cooling to below preheat (interpass) temperature (normally 400 to 600 F) is not permitted until at least 25 per cent or more of the welding groove has been filled.

Pipe Fabrication Institute Standard ES(M)8–1958 states that: "Welding on 1%Cr-½%Mo to 3%Cr-1%Mo materials may be interrupted at any time, provided that a minimum of at least ⅜-in. thickness of weld deposit or 25 per cent of the welding groove is filled (whichever of these amounts is greater).

The American Welding Society, in Publication D10.3-55T, Recommended Practices for Interruption of Heat Treatment Cycles for Low Chromium-Molybdenum Steel Piping Materials, suggests that "where an interrupted procedure is followed, the weld deposit prior to interruption should never be less than one-third the wall thickness or two layers, whichever is greater."

Fig. 14. Purging fixtures for protecting underside of pipe weld by displacing air with inert-gas or nitrogen

On pipe of 3-in. wall thickness the weld area could be cooled only after ¾-in. of the groove thickness has been welded. At this thickness critical cracks in the root pass frequently are no longer detectable by radiographic techniques.

Since radiographic films tend to blacken when exposed to temperatures exceeding 140 F, special fixtures are necessary which keep the film temperature below 120 F. This is effectively accomplished by means of the flexible water-cooled hot-radiography fixtures illustrated in Figs. 11 and 13. With a pipe interpass temperature of 550 F on 12-in. Sch. 160 pipe, the temperature at the center of the fixture will not exceed a reading of 115 F.

Cooling of the copper sheet is accomplished by passing water through flexible tubing soldered to both sides of the copper sheet. Cooling by flowing water between two layers of copper sheet supporting the film would be undesirable since corrosion of the copper sheet or the deposition of mineral constituents between the sheets underneath the radiographic film may result in erroneous radiographic patterns. THE END

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Operating Tips on Transformers

The author began his discussion of transformers in the October issue, with practical advice on how to receive a transformer and prepare it for service. A third article will discuss maintenance

By A. J. BECKER *

IT IS ADVISABLE to complete certain tests before energizing a transformer according to ASA standards C57.12–1956. Minimum testing should at least include resistance measurements, ratio tests, polarity and phase relation, and insulation resistance.

After applying full voltage, allow the transformer to soak for one or two days without load. Transformer should be kept under observation during this time and also during the first few hours of operation under load. After several days, check the oil for moisture and the gas space for oxygen.

Do not run a water-cooled or forced oil-cooled transformer continuously, even at no load, without proper circulation in the cooling system.

The rated kva of a transformer is the load which can be carried continuously at a rated voltage and frequency without exceeding the specified temperature rise. A transformer should have a normal life at rated kva if the average ambient temperature under operating conditions does not exceed 30 C and the peak ambient temperature does not exceed 40 C.

Transformers with a 55 C rise have a temperature rating of 55 C average copper rise, and 65 C hottest spot temperature rise.

Insulation ages with respect to temperature in accordance with a "degree rule." For each 8 C increase in temperature, the aging rate doubles for 55 C rise transformers.

Before Loading

Before loading any transformer, a study should be made to determine if factors such as oil expansion, pressure and capacity of bushings, tap changers, leads, connections, etc, might impose limitations, rather than thermal capabilities of the transformer.

The simplified rules shown in Table I have been reproduced from a table in ASA C57.92.

Loading on the basis of ambient temperature, oil temperature, and load factor or load cycle is based on normal life expectancy; however, under emergency conditions the load may be increased above these values with a moderate sacrifice of life. An average loss of life of one per cent per year is considered reasonable during emergency operations. The emergency capabilities of transformers should be determined by ASA guides on an individual basis.

Most apparatus produces some noise as it does work, and the transformer is no exception. Fortunately, noise can generally be controlled to the point where it is not disturbing. Where noise occurs in core, sideframes, assembly, tank, radiators or fixtures, it can usually be corrected by tightening the part involved. Resilient pads may be used to reduce sound with dry-type transformers but have little value for oil-filled units.

If noise is objectionable and must be reduced, here are some ideas that will help lower the sound level: landscaping — trees and shrubs will reduce level by several decibels; use of partial or complete enclosures by wall of sound absorbing or restricting material; removing all reflecting or amplifying materials or surfaces.

Surge Protection

Good surge protection must meet several basic requirements. It must protect the apparatus. It must restore normal conditions following operation. It must be capable of discharging all surges to which it is subjected without damage to itself.

Gaps are not practical by themselves. They do not provide adequate protection for steep front voltage waves unless the gap is made small, and this opens the possibility that ordinary switching surges may spark over gap. Arc persists until short cir-

Table I. These simplified rules for loading have been reproduced from ASA C57.92

	Loading on Basis of Ambient Temperature		Loading on Basis of Load Factor	
Type of Cooling	Per Cent of Rated Kva Per Degree C Decrease Load for Higher Ambient	Per Cent of Rated Kva Per Degree C Increase Load for Lower Ambient	Increase in Per Cent of Rated Kva	Maximum Per Cent Increase
Self-Cooled	1.5	1.0	0.5	25
Water-Cooled	1.5	1.0	0.5	25
Forced Air-Cooled	1.0	0.75	0.4	20
Forced Oil-Cooled	1.0	0.75	0.4	20

Table II. This shows at a glance daily loads to give units normal life expectancy

	Times Rated Kva								
Time, Hours Initial Load *	Self-Cooled and Water-Cooled Transformers			Forced Air-Cooled Transformers Rated 133 Per Cent or Less of Self-Cooled Rating			Forced Air-Cooled Transformers Rated More than 133 Per Cent of Self-Cooled Rating and All Forced Oil-Cooled		
(Per Cent)	90	70	50	90	70	50	90	70	50
½	1.59	1.77	1.89	1.45	1.58	1.68	1.36	1.47	1.50
1	1.40	1.54	1.60	1.31	1.38	1.50	1.24	1.31	1.34
2	1.24	1.33	1.37	1.19	1.23	1.26	1.14	1.18	1.21
4	1.12	1.17	1.19	1.11	1.13	1.15	1.09	1.10	1.10
8	1.06	1.08	1.08	1.06	1.07	1.07	1.05	1.06	1.06

* Percentages fix the load which is assumed to exist before the short-time load is applied. Use either average load for two hours previous to load above rating or average load for 24 hours (less overload period), whichever is greater.

Ambient temperature assumed for this table is 30 C for air and 25 C for water.

As the loads may be applied once every 24 hours, and as there is some evidence that the rate of insulation deterioration at about 100 C doubles with less than 8 C increase in insulation temperature, the values have been based on 4 C rather than on 8 C.

* Service Engineer, Allis-Chalmers, Pittsburgh Works

cuit is cleared by a circuit breaker, recloser, or fuse. An outage then follows.

Expulsion-type has the advantage of gap plus a means of clearing the gaps after sparkover. Its disadvantage is that if fault capacity exceeds certain limits, arrester will not function properly.

Valve-type offers big advantages. As voltage applied to the arrester increases, resistance of the element decreases, permitting more current to flow, thus retarding further increases in voltage. As the surge is discharged, the current and voltage decreases and the resistance increases to prevent the flow of power-follow current. A valve-type arrester usually has a few small gaps in series with the gap material so that under normal operating voltage no leakage current will flow through the arrester.

Caution: Connect lightning arrester solidly to the ground with as short a lead as possible. Be sure the tank is solidly grounded to prevent hazardous voltage between tank and ground. Where utilities prefer to operate with tanks ungrounded, a gap is used to limit voltage from tank to ground under surge conditions.

Voltage rating of an arrester is determined by the maximum normal line-to-neutral voltage that may occur.

For a grounded system, arrester is equal to line-to-line voltage. For ungrounded system, arrester rating is generally equal to 80 per cent of the line-to-line voltage. Voltage rating of arresters for use on a grounded system depends on the type of grounding used.

What About Oil?

At present there are two types of transformer insulating and cooling liquids. Most popular is the highly refined straight run mineral oil, a crude petroleum distillate. The other is a synthetic liquid called Askarel, which is non-flammable.

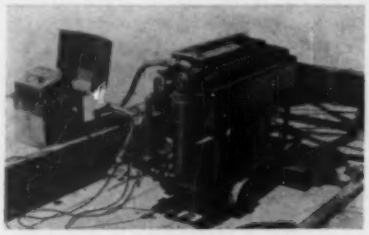
Oil has a double function: first as a coolant (therefore it must have low viscosity, low temperature characteristics); and secondly, it serves as an insulator and must be free of impurities such as water, certain acids, fats and compounds that affect the insulating qualities.

When filling a transformer with oil, use only approved transformer oil. Use of unknown types can cause trouble. In sampling, be certain that containers are of sufficient size and spotlessly clean. Do not contaminate the sample oil in handling.

Dielectric test shows if the oil has sufficient electrical strength. Low dielectric indicates moisture and/or other contaminants present. ASTM requires the oil to be tested in a cup with 1-in. discs, 1/10-in. apart. Dielectric strength of new transformer oil should be at least 26 kv. For used oil, 22 kv is considered minimum. Liquid testing below this value should be filtered through a blotter paper press.

As for filtering — a blotter-type filter is best suited for transformer oil. Filtering oil through a fuller's earth type of conditioner has the effect of over-refining and removes some of the natural inhibitors; however, the liquid can be conditioned by adding synthetic compounds as an inhibitor afterwards.

Di-tertiary-buytl-para-cresol, or DBPC, is sometimes added to both new and old transformer oil as an oxidation inhibitor to extend the life of the oil. Materials in most new transformers are compatible with the DBPC, but it is best to consult the transformer manufacturer before using it in older transformers.



Processing of oil through the filter press

It takes many tests to determine the condition of the oil. Each contributes some information on its condition. Analysis of several tests will show if oil is still serviceable. Oil in service should be tested for dielectric, color, odor, acidity, interfacial tension, and sludge.

Color: N.P.A. classifies new oil color, starting with No. 1 as the top condition.

Odor: burnt odor indicates arcing or overheating.

Acidity: new oil should not exceed 0.03 mg, while aged oil exceeding 1.0 should be investigated and changed. Some acid compounds produced by oil aging may attack the insulation. Low acid number is desirable for new oil. High acid number indicates oil should be replaced or reconditioned. Tests for acidity are usually made in a chemical laboratory.

Table III. Summary, insulating oil tests

Tests	Units	New Oil	Aged or Contaminated Oil
Dielectric strength	Volts	26,000	22,000
Color	NPA No.	1	6
Odor		Fresh	Burnt
Acidity	Mg KOH/gm	.03	1.5
Interfacial tension	Dynes/cm	40	15
Sludge	Per cent	None	.2
Pour point	Temp	−40 C	—
Flash point	Temp	132 C	—
Fire point	Temp	149 C	—
Specific gravity	Weight	.91	—
Viscosity 37.8 C	Seconds	63	—
Steam emulsification	Seconds	25	200
Power factor	Per cent	1	10

IFT Testing

Interfacial Tension: the IFT is used to indicate changes in the condition of oil and is particularly sensitive when changes are in the initial stage. It is essentially a measure of surface tension strength of oil in contact with water. Acidic acids and other contaminants affect the IFT value. New oils may show an IFT value of 50 dynes per centimeter, while aged or contaminated oil value may be below 15 dynes. This test is usually made in a laboratory, although there are kits available for field testing that give reliable indications and rapid spot check for both acidity and interfacial tension.

Sludge is an indication of the extent of oil deterioration and is formed by oxidation, acids, hot spots in the coil, and arcing contacts. The test for sludge is also performed in the laboratory.

To determine if the oil is suitable for the transformer, particularly when adding make-up or checking new oil, the following tests should be considered — pour point, flash and fire point, specific gravity, viscosity, emulsification number, and power factor.

Askarel is a non-flammable liquid which is quite stable and will not oxidize or form sludge. Electrically, it is comparable to transformer oil, but is more readily contaminated. Askarel units are usually of sealed design. The liquid has a very low flow point, high dielectric strength, and absolutely no burning point. Due to its weight and gravity, moisture will rise to the top of the liquid, being inversely that of conventional oil. Filtering must be done in a modified filter press using fuller's earth. Papers alone will not do a satisfactory job. Cleanliness is most important, not only for the workmen but also for the equipment and anything associated with the liquid. THE END

WANT COPIES of these transformer articles? Write the Editor, POWER ENGINEERING, or jot down Transformers on the postcard inserted in this issue

Headaches of Package Boiler Control —And How to Cure Them

Revolution is brewing in package boiler control. The author looks at present systems, tells what new concepts are needed and why

By A. W. HINDENLANG*

PACKAGED water tube boiler is a bright new planet in the steam generator firmament, but its brightness is obscured by a host of alien, man-made satellites. These are the paradoxes, conflicting claims, false hopes, and misunderstandings surrounding the packaged boiler today. Most of these difficulties are not engendered by the boiler itself but by its firing arrangement comprising the burner, with its safety and combustion control systems.

These packaged boilers are generally defined as water tube steam generators that are completely shop fabricated and assembled and which may be shipped on a flat car or truck with all auxiliary equipment in place. With its advent in 1950, the packaged boiler achieved immediate popularity.

Its low first cost has always been an important part of its market appeal. For example, a 50,000-lb-per-hr boiler with fan, firing equipment, and controls costs only slightly more than $50,000. At an equivalent rate per pound of steam, a domestic heating boiler (a high volume production item) should sell for about $100 instead of the $300 it actually costs. Other popularity factors are minimum space requirements and less time for delivery than was formerly spent on contract processing and engineering of boilers of a similar size. It is only natural that this product should have appealed to a wide and varied market. It is precisely here that the story of our problem begins.

Let's examine some of the paradoxes that arise in this variegated market. We find among our purchasers the giants of the public utility industry, the small hospitals and high schools, the major refineries, and the little dye house operators. We encounter package boilers operating behind locked doors with no one in attendance, and we see others running smoothly along with two and three operators in the boiler room. We know of package units which are instrumented to record and integrate or indicate all flows, pressures, and temperatures — and others which must be operated by the "seat of the pants" method.

Thirty-five per cent of the average package boiler specification is devoted to the boiler, which represents 85 per cent of the total cost. The remaining 65 per cent of the specification covers the burner and control system, which accounts for only 15 per cent of the investment. Here indeed is a case of the tail wagging the dog. And here is where much of the difficulty with control systems arises. We will consider later why many of these specifications beget systems which bear little resemblance to what the user actually needs.

Other paradoxical cases? There are a host of them. Consider a chemical process where steam is required around the clock. In far too many cases of this type only a single packaged boiler will be installed, despite the fact that an outage can cost thousands of dollars per day. This common situation exerts tremendous pressure on the control system designer since every switch, wire, regulator — in short, every device he uses — is the potential source of an outage.

Deplorable Explosion Record

Perhaps our most vexing paradox is that the package boiler has a deplorable furnace explosion record, Fig. 1, in spite of having more protective devices than any of its predecessors. It seems paradoxical, too, that the insurance underwriters show little concern over the insurgent use of a boiler with a dismal furnace explosion history. This probably comes about because the cost of repair is relatively insignificant and injuries to personnel are few and far between.

This then is the background for the headache that is presently throbbing away: package boiler control. The exact and critical nature of this control problem evolves from the following criteria:

1. Control system must be a complete package capable of shipment mounted on the boiler.

2. System must be complete, comprising combustion control (fuel and air flow), limit control (protection against operating malfunctions), and flame failure control.

3. Controls must be standardized and almost pre-packaged to meet the extremely short delivery schedules and keep engineering costs at a minimum.

4. Despite the mandatory standardization requirement, the system must be suitable for a wide variety of fuels under varying pressure conditions.

5. Control arrangement must be so designed as to be acceptable to consulting engineers and insuring bodies whose specifications have been largely inconsistent, even within a given agency.

6. All control components should be specifically designed for this very special service.

7. Cost of control components must be kept to very nearly the absolute minimum. This figure has been between four and five per cent of the total selling price of the unit. This presents a marked contrast to the 35 to 45 per cent value for the controls system of a jet bomber.

8. While the controls must be precise, efficient, and fast-acting, the system must not assume complexity beyond the grasp of operating or maintenance personnel.

9. Admitting that these systems cannot be made "damn-fool-proof" we must build them to be as "fool-proof" as possible.

10. Above all, our control systems must be safe and should offer protec-

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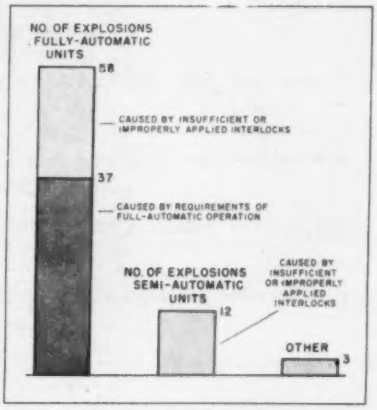


Fig. 1. Chart analysis of package boiler explosions, showing types and causes

tion against as many hazards as possible. Yet it is imperative that we build in reliability and we know that the reliability of a system decreases exponentially as the number of components increases.

11. To complicate the criteria still further, there has been a demand that these boilers operate "fully-automatic." Stripped of the frills, this means that the units shall operate without attendance and will shut down and start up without any attention from an operator. Rising labor costs have made this feature most desirable.

Designing a system to meet all these criteria is patently an impossibility, using the tools available to us today. How then are we to approach this problem and achieve the optimum design?

It has been wisely said that the first step in a good design approach is to examine what has been done, and then to reject all of it if necessary.

With the illuminating clarity of hindsight it is easy to recognize that the package boiler program started out about six years ago with three strikes against it.

STRIKE ONE! Control system designers were sold a flame safeguard device with a built-in timer which "programmed" the steps necessary to start up and shut down the burner automatically. Contrary to popular opinion this device was not a panacea; in fact it was at the root of most of our troubles. This "brain" device was in reality a hand-me-down from the fire tube package boiler: a low-pressure, low-capacity-type unit with vastly different firing problems. As one result we were saddled with a "post-purge," a period of 15 seconds or more after a shutdown when the fan continues to run. Try to imagine a shutdown with a furnace saturated with a combustible mixture, a furnace with bits of metal or refractory hot enough to ignite this mixture, and then try to imagine a more hazardous expedient than forcing air (the third ingredient for explosion) into this furnace. Yet we do this even today, and every year hundreds of specifications are written insisting on this deadly post-purge. I have in my files a letter from the manufacturer of one of these devices stating that the only reasons for "post-purging" are to furnish air for burning the residual oil entering the furnace during spin-down of rotary cup burners, and to furnish air for combustion of gas from slow-closing gas safety trip valves. Since these reasons are without validity with water tube packaged firing equipment, we find ourselves being forced to follow a most dangerous practice that has absolutely no value.

Even more annoying than this and other cases (such as the fact that though widely heralded as not recycling on flame failure, these units can and do recycle on flame failure) is the painful truth that this type of controller contributed to the enthusiastic adoption of:

STRIKE TWO! The Fully-Automatic Concept. It is difficult to find a parallel which hindered the normal development of a product so much as the "fully-automatic" concept. This idea was born in the programming timer that was carried over from the smaller, low-pressure fire tube boilers. It gave purchasers the impression that their steam generating plants could be operated just as their home heating plants functioned, starting

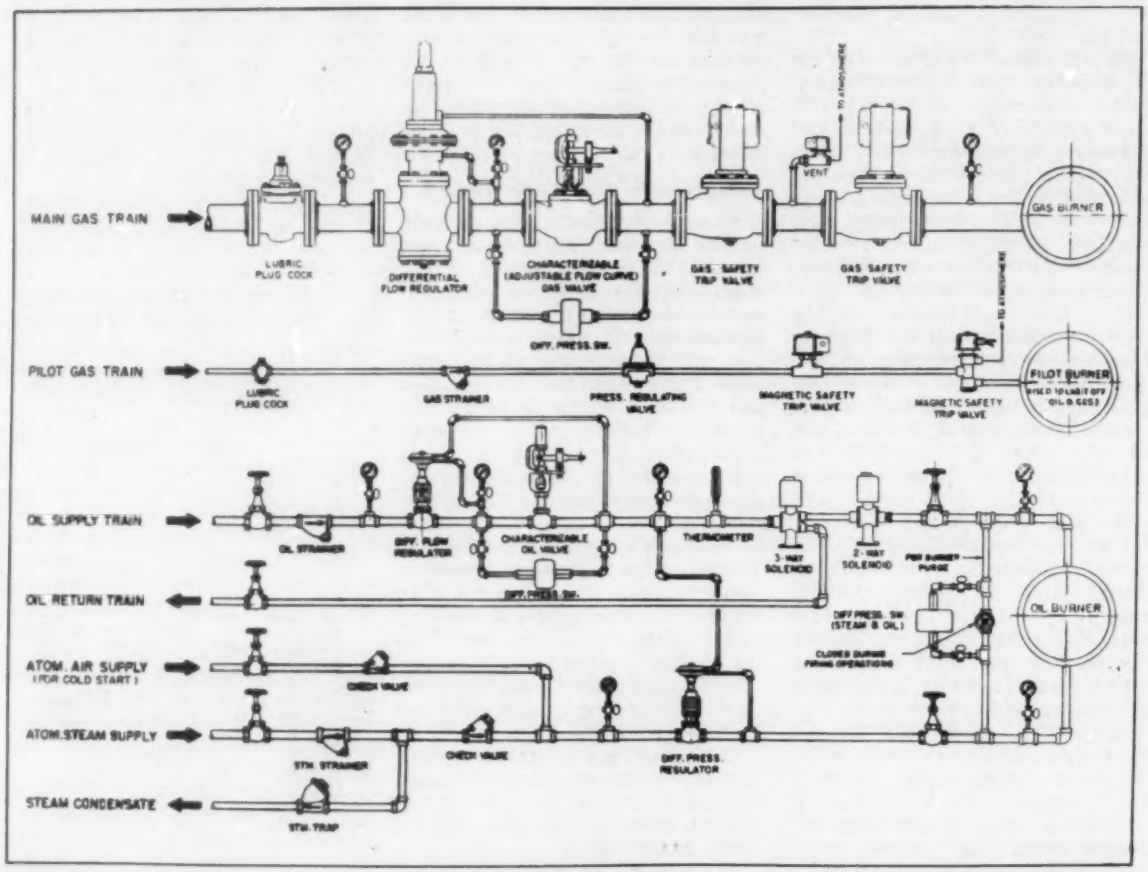


Fig. 2. Flow diagram of a combination burner arrangement shows complexity of the control system for automatic operation

up on a demand for heat and shutting off when the demand was satisfied. This basic idea had insidious overtones. Instead of starting and stopping the burner solely on demand for heat, many other safety devices were allowed to start and stop burners automatically. Among these devices were low water cut-offs, low oil temperature cut-offs, high and low fuel pressure interlocks, atomizing steam safety switches, and others.

None of these limit devices should be allowed to restart a burner. The boiler operator should always be aware of the condition that caused his unit to shut down and should take remedial action instantly.

In spite of these obvious truths, economic pressure exerted by users who planned on reducing labor costs by replacing operating personnel with fully-automatic burners led to the indiscriminate sale of this type of unit. Thus, boiler manufacturers who do not believe in operating power boilers without operating personnel in attendance found themselves selling fully-automatic units to people who intended to run them with no operating personnel available.

Figure 1 indicates the extent of the difficulty caused by the "full-automatic" concept of firing packaged boilers. Fully 50 per cent of the furnace explosions in this study are traceable to the attempt to operate these firing systems without supervision.

Even in those plants where operators were in attendance on fully-automatic units, we find explosions caused by abysmal ignorance on the part of operating personnel. After all, they were trained only to push a button, and emergencies found them woefully unprepared.

Finally, the components available to system designers simply did not (and still do not) possess the reliability required for full automatic, unattended operation. The problem of getting reliable components developed for a low margin, low volume market is by no means an easy one. I believe that only by the concerted action of the industry will we be able to have manufacturers develop the kind of components we need.

STRIKE THREE! The third strike against control system designers also sprang from an idea. The packaged boiler was to be a 100 per cent standard, off-the-shelf product. It was proposed to ship these units from stock like refrigerators and plug them in like radios. Pricing procedures were set up, based on this idea. Proposal groups and engineering staffs were organized to handle "standard" units.

When the rush of business developed, it became evident that every prospective purchaser and most consulting engineers had different ideas on how these boilers should be fired, controlled, and instrumented. Burner and control specifications became longer and more involved and the "standard" product was a rarity indeed.

Frequently the burner or boiler manufacturers had more work to do than they would normally encounter in handling a utility boiler contract. This meant a terrific work load on small staffs and acceleration of engineering to a critical point. Engineering had to be done in days rather than months. Frequently it takes several months to circulate flow meter data sheets from meter manufacturer to boiler manufacturer to consulting engineer to purchaser and back

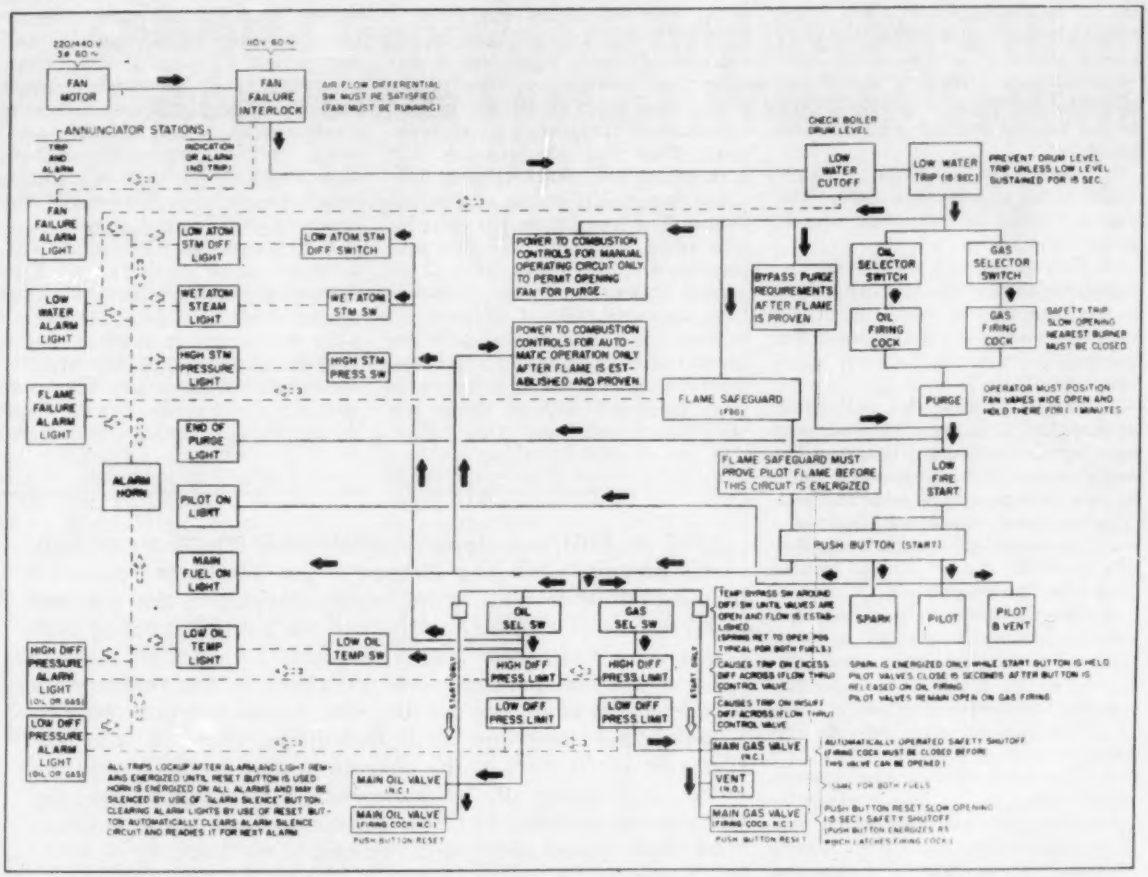

FAN MOTOR
FAN FAILURE INTERLOCK
AIR FLOW DIFFERENTIAL SW MUST BE SATISFIED (FAN MUST BE RUNNING)
ANNUNCIATOR STATIONS
TRIP AND ALARM
INDICATION OR ALARM (NO TRIP)
CHECK BOILER DRUM LEVEL
LOW WATER CUTOFF
LOW WATER TRIP (15 SEC)
PREVENT DRUM LEVEL TRIP UNLESS LOW LEVEL SUSTAINED FOR 15 SEC.
FAN FAILURE ALARM LIGHT
LOW ATOM STM DIFF LIGHT
LOW ATOM STM DIFF SWITCH
LOW WATER ALARM LIGHT
WET ATOM STEAM LIGHT
WET ATOM STM SW
HIGH STM PRESSURE LIGHT
HIGH STM PRESS SW
FLAME FAILURE ALARM LIGHT
END OF PURGE LIGHT
ALARM HORN
PILOT ON LIGHT
MAIN FUEL ON LIGHT
POWER TO COMBUSTION CONTROLS FOR MANUAL OPERATING CIRCUIT ONLY TO PERMIT OPENING FAN FOR PURGE
POWER TO COMBUSTION CONTROLS FOR AUTOMATIC OPERATION ONLY AFTER FLAME IS ESTABLISHED AND PROVEN
BYPASS PURGE REQUIREMENTS AFTER FLAME IS PROVEN
OIL SELECTOR SWITCH
GAS SELECTOR SWITCH
OIL FIRING COCK
GAS FIRING COCK
SAFETY TRIP SLOW OPENING NEAREST BURNER MUST BE CLOSED
FLAME SAFEGUARD (F30)
PURGE
OPERATOR MUST POSITION FAN VANES WIDE OPEN AND HOLD THERE FOR (MINUTES
FLAME SAFEGUARD MUST PROVE PILOT FLAME BEFORE THIS CIRCUIT IS ENERGIZED
LOW FIRE START
PUSH BUTTON (START)
OIL SEL SW
GAS SEL SW
SPARK
PILOT
PILOT B VENT
HIGH DIFF PRESSURE ALARM LIGHT (OIL OR GAS)
LOW OIL TEMP LIGHT
LOW OIL TEMP SW
HIGH DIFF PRESS LIMIT
LOW DIFF PRESSURE ALARM LIGHT (OIL OR GAS)
LOW DIFF PRESS LIMIT
START ONLY
CAUSES TRIP ON EXCESS DIFF ACROSS (FLOW THRU) CONTROL VALVE
CAUSES TRIP ON INSUFF DIFF ACROSS (FLOW THRU) CONTROL VALVE
SPARK IS ENERGIZED ONLY WHILE START BUTTON IS HELD
PILOT VALVES CLOSE 15 SECONDS AFTER BUTTON IS RELEASED ON OIL FIRING
PILOT VALVES REMAIN OPEN ON GAS FIRING
MAIN GAS VALVE (N.C.)
VENT (N.O.)
MAIN GAS VALVE (FIRING COCK N.C.)
AUTOMATICALLY OPERATED SAFETY SHUTOFF
SAME FOR BOTH FUELS
PUSH BUTTON RESET SLOW OPENING (15 SEC.) SAFETY SHUTOFF
MAIN OIL VALVE (N.C.)
MAIN OIL VALVE (FIRING COCK N.C.)
PUSH BUTTON RESET
ALL TRIPS LOCK UP AFTER ALARM AND LIGHT REMAINS ENERGIZED UNTIL RESET BUTTON IS USED. HORN IS ENERGIZED ON ALL ALARMS AND MAY BE SILENCED BY USE OF "ALARM SILENCE" BUTTON. CLEARING ALARM LIGHTS BY USE OF RESET BUTTON AUTOMATICALLY CLEARS ALARM SILENCE CIRCUIT AND READIES IT FOR NEXT ALARM

Fig. 3. Function diagrams like this one are now being tested to make control drawings more easily understood by operators

through the entire chain. Difficulties involved in matching time-honored routine to extremely short delivery schedules are well nigh insurmountable. The most critical point, however, is that crash program engineering and purchasing, which becomes necessary on these non-standard units, inevitably lead to all kinds of installation difficulties and operating misfortunes.

These, then, are the three strikes that overshadowed packaged boiler control programs from the beginning. In addition there have been mistakes of detail design and application which are being eliminated by study and experience.

The question to be answered for successful future designs now resolves itself into "how can we eliminate the 'three strikes' that have plagued us and take full advantage of all that we have learned?"

Successful design approach must include these ten commandments as basic design criteria:

1. The boiler operator is a vital factor in safe, efficient operation. He need not be in continuous attendance, *but he must perform each and every light-off.*

2. Unnecessary trips or shut downs are to be rigorously avoided. High steam pressure, for instance, need not be the source of a trip. Many individuals today think of a high steam pressure switch as a safety device, so far has its original concept been perverted.

3. Hazardous conditions, which could cause an explosion before the operator could take remedial action, must cause a trip.

4. Control system should be designed so that the operator is required to perform all the proper functions in the proper order. Failing this, the system automatically should abort the start-up.

5. Burners should be redesigned or reapplied to achieve the maximum safe turndown ratios. It is possible and practical to maintain a safe flame in these boilers, with no steam output. This has been accomplished in sufficient cases to indicate good chances of success for a concentrated burner improvement program.

6. Timing of the light-off and operating sequence must be what is required for these units, and not merely something that was thought suitable for another product.

7. The system must indicate the exact cause of every boiler trip.

8. The combustion control system must be rugged, reliable, and above all simple. Intricate combustion controls are to be avoided. The claimed efficiency gains cannot be realized without thorough, precise, and periodic checking and maintenance. It has been reliably demonstrated that simple parallel controls are more satisfactory where only infrequent instrument maintenance is available or practical, provided that fuel flow is compensated for normal variations.

9. The system must be graphically represented so that it becomes comprehensible to those who must operate and maintain it, even though they may have no background as control specialists.

10. Finally, all components must be selected with special care. Cost should be the last consideration, with safety and reliability heeded first.

A control system designed to these "ten commandments" is illustrated in Figs. 2 and 3. The system is predicated on controlling a burner which can be turned down to no steam output. Figure 3 is an example of a method, currently being tested, to make electrical system drawings more understandable to the average boiler operator.

Fuel-Metering

It will be noticed that the combustion control system is a simple parallel type with compensated fuel flow control. That is to say the differential flow regulators guarantee a preset fuel flow for every position of the control valve, regardless of upstream or downstream flow conditions. This type of system is also known as a "fuel-metering" arrangement. Fuel flow compensation has been added, not primarily as an efficiency agent, but rather as a safety device. The fuel differential switches now check that both fuel flow and pressure are within safe limits at all points in the firing range. This was formerly accomplished in part by high and low fuel pressure switches, which could not signal improper flow rates. Thus, scope and safety have been increased without using any additional interlocks.

It may be said that this type of system is reactionary. Indeed it is, but it is high time we had a reaction. For years we have accepted substitutes, cast-offs from other industries, and false ideas and practices which had no basis in fact. It is to be devoutly hoped that these new control systems, based on fact and common sense, will attract an immediate following among users and specifiers. It is only natural that systems like this will appeal to those who operate package boilers.

In closing, here are a few suggestions for those who are faced with the task of specifying and purchasing packaged boilers:

1. Always look for an integrated firing arrangement. The burner, pilot, fans, combustion, and safety controls are highly interdependent.

2. If it seems essential to specify a "special" system, don't expect the same delivery you could get with a standard arrangement. The boiler manufacturer will try to meet your schedule, but somewhere down the line of supply your job will suffer because someone is over-pressured. Be fair to yourself and allow time for reasonable procedures.

3. With your request for bids, furnish complete and exact information needed for proper quoting and engineering. This includes fuel characteristics and pressures, current characteristics, stack and breeching conditions, steam and feedwater pressures, load characteristics, and the like. Guessing at this information usually leads to substandard performance and dissatisfaction.

4. Try to make your specification a "performance specification." That is, specify precisely what the unit or system is required to do. Better results are more often attained by this type of "spec" than by the restrictive type which tries to mandate every last detail and minor item of equipment. THE END

NEXT MONTH, in its January, 1960 issue, POWER ENGINEERING will present "Changing Shapes in the World of Power," a special issue devoted to the rapidly-developing and fascinating subject of computer control and the automatic power plant concept. Twelve top control engineers, all expert analysts of automation practices and principles in the power field, will tell this story, for the first time, in non-technical, easy-to-understand language and illustrations. From its computer primer to the story of the ultimate in push-button control and the explanation of "sophisticated" data-logging and performance analysis, that issue promises to be one that will be re-read, talked about, and referred to for years.

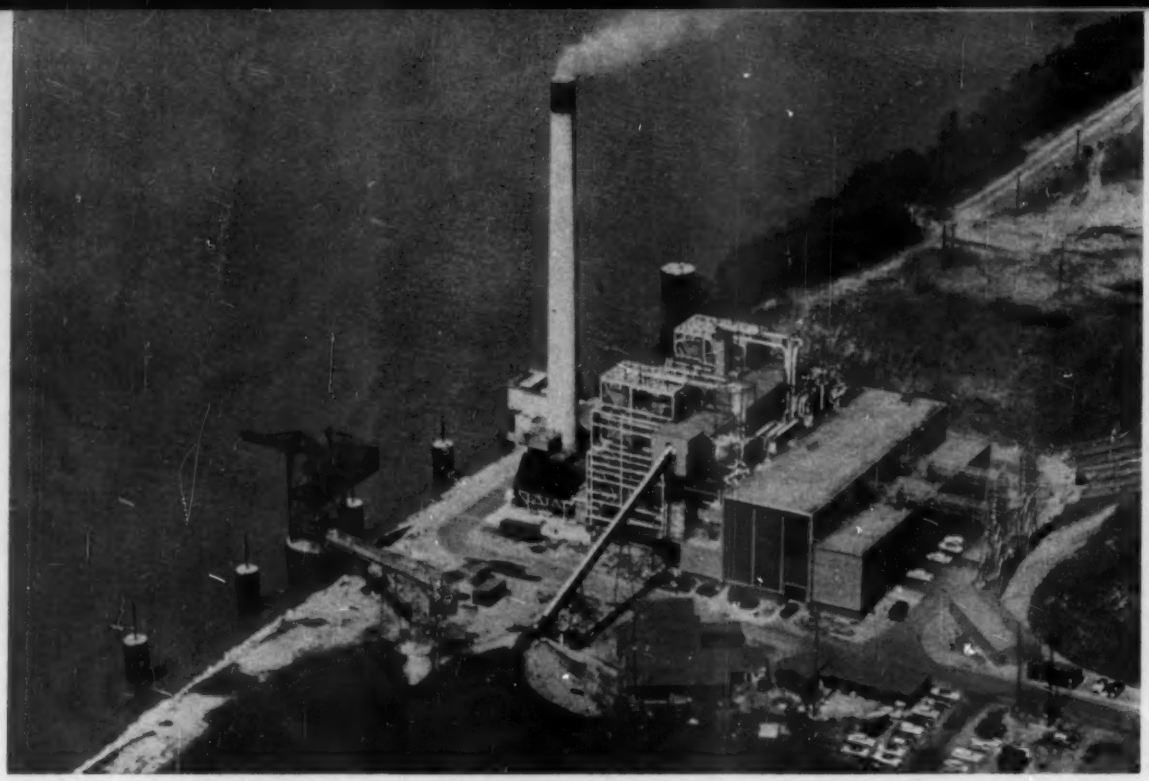


Fig. 1. This photo of Weaton Station, owned by St. Joseph Lead Co, shows the importance of present-day industrial plants

Oversize Generators and Steam-Driven Feed Pumps Feature Weaton Station

Completed in 1958, Weaton Power Plant in Monaca, Penna, utilizes two oversize generators for anticipated phase unbalance. Diesel-driven generators supply power to the auxiliaries for start-up

By W. B. BALL *

IN DESIGNING industrial power plants for today's economy-minded manufacturers, more than usual consideration must be given to reliability, simplification, and low operating cost. Nowhere is this more important than in the design of isolated plants which must be depended upon to supply uninterrupted electric power.

Following such criteria, Kaiser Engineers designed and constructed the new George F. Weaton Steam Power Plant for St. Joseph Lead Company at Monaca, Pennsylvania. This 100,000-kw plant was completed last year and is now in operation, producing electricity for St. Joseph's nearby zinc smelting furnaces.

New Weaton Station consists of two turbine-generator units, each of 56,000-kw maximum capability. Because phase unbalance was expected in operation, oversized generators were selected for the turbines. Designed for tangential firing of pulverized coal and equipped with superheater, reheater, economizer, and air heater, the steam generators are single-drum, natural-circulation, water-cooled-furnace type, reheat units. Each boiler unit furnishes 375,000 lb of steam per hour at 1850 psig and 1000 F at the superheater outlet. They will reheat 278,000 lb of steam per hr at 1000 F and 424 psig at the reheater outlet, with feedwater flow at 454 F. A maximum main steam flow of 425,000 lb per hr can be tolerated for short periods.

Each of the steam generator systems was made independent of the other by having boilers and auxiliaries arranged on a unit basis where practical. Heat cycle efficiency was increased and cold startup made possible by utilizing turbine-driven boiler feed pumps for each boiler. This feature assured greater reliability. Each boiler feed pump is designed to supply the full capacity of the units. The turbine on the main boiler feed pump is supplied steam from the cold reheat line and is intended for operation from approximately 60 per cent load to full load.

For operations at less than 60 per cent load, an auxiliary supply of steam is available from pressure-reducing stations at 625 psig. The auxiliary boiler-feed-pump turbine is normally supplied with 625-psig steam pressure but is capable of operating from approximately 250-psig pressure up to the maximum of 625 psig. A 1125-kw diesel-electric power unit was provided to supply the start-up power.

Start-up procedure is to place in operation a circulating-water pump, the boiler fans, and limited auxiliary equipment until power is being generated by the main unit. While the boiler is being brought up to pressure, the feedwater is supplied by a small electrically-driven pump to about 250 psig. At this point, as noted before, the auxiliary boiler feed pump takes over and from then on will supply the boiler feedwater. After

*Project Engineer, Kaiser Engineers

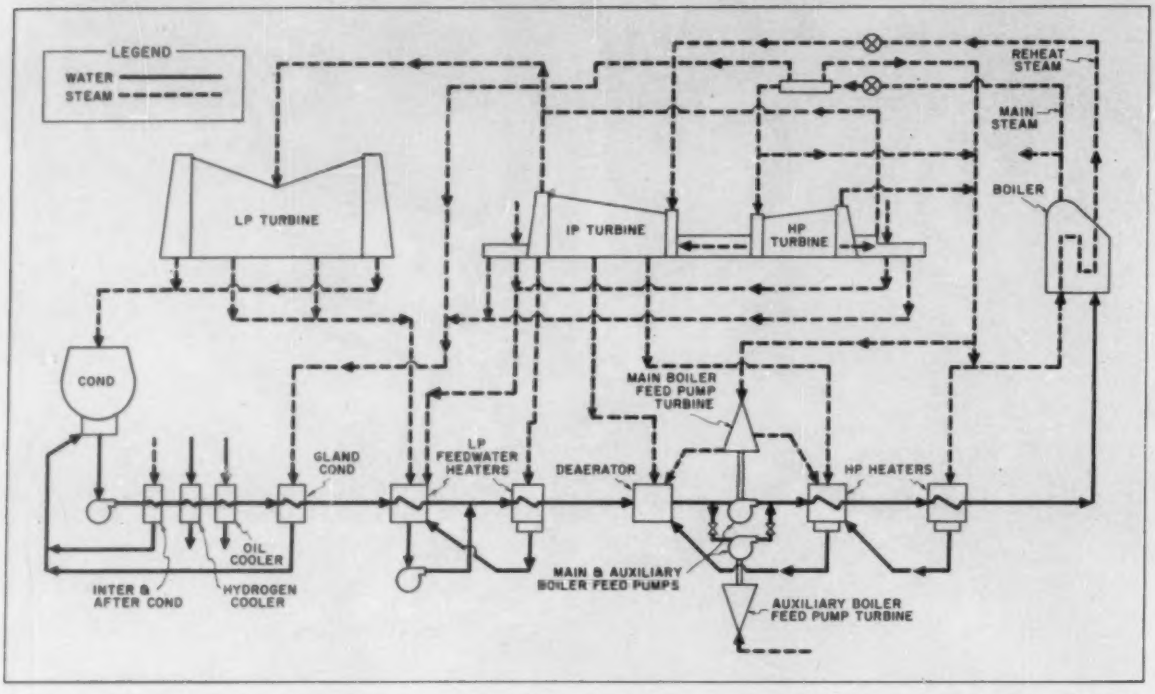


Fig. 2. Flow diagram of the station. Note steam-driven boiler feed pumps, discharging and even extracting to the heaters

the unit is synchronized, the generation of power may be started and the diesel unit cut off.

Auxiliary boiler feed pump is always kept on a slow-speed idle and arranged for automatically picking up the load upon failure of the main boiler feed pump for any reason. The system will remain in operation in this way until it is manually switched over to the standard main boiler feed pump. The main boiler feed pump has an extraction point for supplying steam to heater No. 4, and exhaust from the turbine is taken to the deaerator. The auxiliary boiler feed pump exhausts either into the main unit condenser or, under emergency conditions, to the atmosphere.

For the two 50-mw units, the plant heat rate is expected to be approximately 10,200 Btu. During preliminary operations, the best rate obtained with low loads was 10,500. Later operation of a single unit under adequate load revealed a heat rate of 10,300. Actual characteristics of the units, of course, can be determined only after the plant has been in operation for several months. However, it is expected that the heat rate will be 10,000 to 10,200 when both units are in operation at adequate load.

As in most modern steam power plants, extensive use of automatic controls is made. For each boiler unit, a complete, automatic combustion control system was provided to regulate combustion rate in accordance with the power demand to maintain a constant steam pressure at the turbine throttle. This control system also regulates furnace draft and prevents positive pressure; and it maintains steam flow and air flow over the design load range to assure the most economical combustion.

Measurements for Controls

Primary regulation of steam temperature is accomplished by changing the nozzle position of the tilting coal burners. The boiler firing rate is set by control of the coal-feeder regulator, exhaust-damper regulator, forced-draft-fan-vane regulator, and induced-draft-fan-damper regulator. Four variable measurements are used for the controls: main-steam-header pressure, total steam flow, total combustion-air flow, and furnace pressure. Mechanical-draft equipment is interlocked so the forced-draft fan will shut down automatically if there is induced-draft-fan failure or shut-off.

Coal for the plant ultimately will be supplied by river barges. Handling facilities at the river bank can accommodate six barges in sequence and include an electrically-powered haul system for positioning the barges. The special coal unloader and tower is rated at 500-tph free loading but operates at 325 tph for normal service. After unloading, the coal is fed through a 150-ton hopper to a primary crusher, and then by a vibrating feeder to Conveyor No. 1 for transport to the storage area and reclaim hopper.

Conveyors transport the crushed coal from the 90,000-ton-capacity storage area to six 200-ton overhead bunkers at the boilers. The coal is weighed and sampled automatically before reaching these bunkers. Provision was made for eliminating tramp iron at two points in the system.

Although it is not unique, the control panel is extensive and rather fully instrumented. Advantage is taken of the compactness offered by miniature strip-chart recorders. Grouping of instruments and controls was carefully considered to assist the control room operators in carrying out their function. These features, as well as the extensive use of automatic controls, were dictated by the over-all considerations of reliability and simplification.

An example of economy of operation is pointed up in the condenser circulating cooling water. In finalizing designs for this system, KE not only took into account the usual savings obtained in pump costs and operation through siphonage, but further cut expenses by employing an unconventional method of controlling the siphon effect in the outfall pipeline. Instead of using a seal well to maintain and control siphon-

age, the engineers installed a butterfly valve at the pump house on the outfall line. This enables the operators to take advantage of the maximum siphon regain at any condition of flow.

Cooling water is pumped in a 66-in. line from the Ohio River, circulates through the condensers, and then returns to the river by a 42-in. line.

This system was fully described in the March, 1958 issue of POWER ENGINEERING, pages 82–4. The butterfly valve which controls the rate of flow through the circulating water system is operated by a 125-volt d-c motor. The valve varies the pressure drop or head in the outfall piping to compensate for variations in flow rate. The control arrangement prevents the valve from being opened from the control room unless at least one circulating-water pump is running and its corresponding discharge valve is open.

High-efficiency air-pollution control equipment also was installed in the plant. A combination mechanical dust collector and electrostatic precipitator was provided for each unit to remove fly ash before gases are discharged to the atmosphere. The dust collector-precipitator unit was installed in the boiler exhaust-gas system between the air preheater and the induced-draft-fan inlet. This arrangement greatly reduces fan wear from the abrasive fly ash. The air pollution control equipment is intended to meet any future smoke control laws.

Other features that make the Weaton Station one of the most up-to-date steam power plants were the innovations in decoration and wall construction. The principal building walls are red Norman brick base wall, seven feet high, for collision resistance. Above this base wall is galvanized metal siding. The entire south end wall of the building is translucent aquamarine corrugated-plastic panels.

Color Was Important

Color was incorporated early as an important part of the design features of the plant. Thus, the aquamarine panels, fluted galvanized-steel siding and red brick-wall materials add eye-appeal and blend harmoniously with the dull red-colored exterior boilers.

Inside the building the structural framing is light turquoise, set off against the bright, galvanized wall paneling. The turbine bay operating floor is battleship gray, contrasting with turbine-generators painted persimmon color to emphasize their importance as the principal pieces of equipment.

To provide the best possible acoustics and luminosity in the control room, panels of aluminum honeycomb were suspended as a ceiling. Above these panels all structural members, the roof deck, and air-conditioning ducts were sprayed with asbestos acoustic material, which absorbs about half of the sound in the room. There is a 7-ft high wainscot of plastic with off-white finish above it. The rest of the wall is acoustic tile. The control console and panel face are light green.

Coal bunkers were painted yellow to gain as much light reflectivity as possible in an otherwise dark area. In all coal-handling areas, structural members are charcoal black.

Although a power plant for industrial power production may seem an unlikely project for color engineering, the results at the Weaton Station are notable. Good looks cost little more, if any, than mediocre appearance, and have become an accepted part of good engineering. THE END

New Flowmeter Measures Fluids Directly in Pounds

THE LONG SEARCH for a practical industrial instrument to measure directly liquid and gas flow in pounds has resulted in development of a "true mass" flowmeter. The simple, low-maintenance device is designed to measure precisely the weight of flowing fluids with high accuracy over wide ranges of flow rate, pressure, temperature, and density. It does this without additional measurements and corrections for these variables.

First production units of the new instrument — expected to be available early in 1960 — will meter many industrial fluids including naphtha, gasoline and other hydrocarbon liquids, refinery and natural gas, oxygen, and nitrogen, and liquefied hydrocarbon gases such as butane and propane.

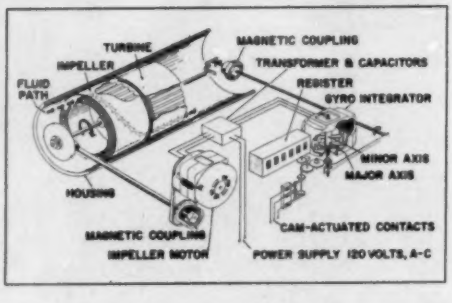
The pound is a fundamental fluid measurement unit used by many industries as a basis for figuring costs, regulating blending operations, measuring yields, determining energy or Btu content, or metering bulk loading operations. However, up to now, commonly used methods of determining fluid flow by mass have first required a measurement of fluid volume. This volume must be either manually or automatically corrected for such variables as fluid temperature, pressure, and density to determine pounds. The manual methods are cumbersome. Automatic correction is complex and presents additional maintenance problems.

In contrast, the new flowmeter requires no in-between calcu'ations, is completely self-contained, weighing about 100 lb, and is designed for long, maintenance-free operation.

The instrument is compatible with automation, being designed to emit a series of electrical pulses, each representing a given weight of fluid. This signal can be used to operate auxiliary equipment such as remote counters, printers, and totalizers.

Several basic contributions to flowmeter technology are incorporated in the instrument. One is a small gyroscope which directly and automatically totalizes flow in a novel manner. Another is a flow-rate sensor, which consists of a constant-speed impeller and a stationary turbine arranged for axial flow.

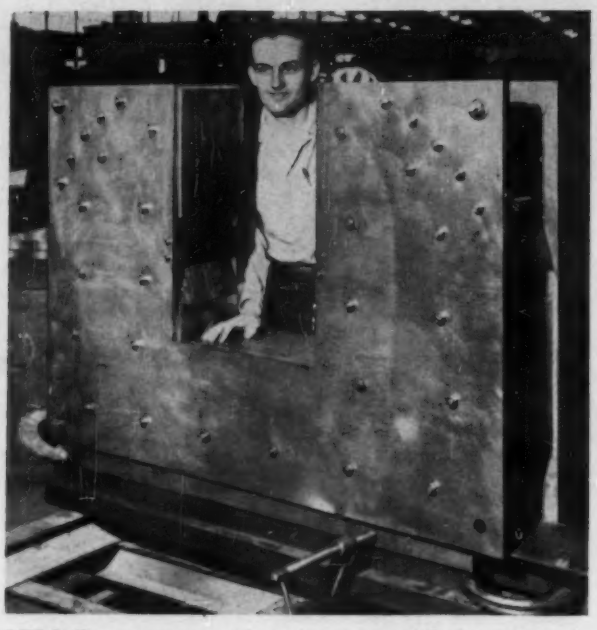
For more information about the new instrument, write The Editor.



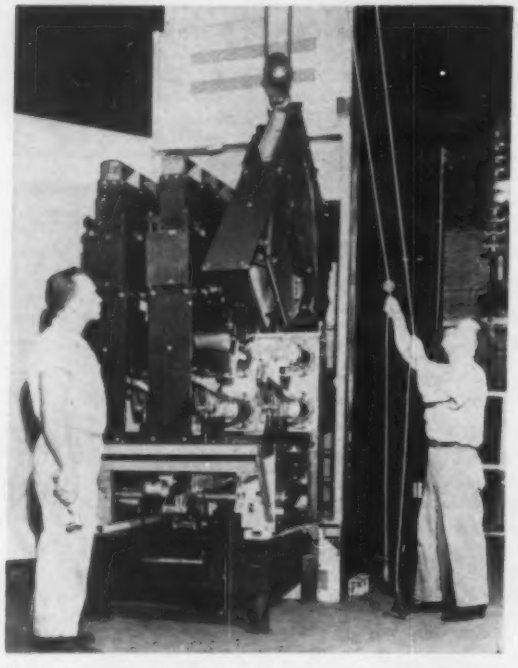
Schematic showing operation of mass flowmeter. Flow-rate sensor consists of impeller and stationary turbine. Impeller gives twist to fluid. Turbine removes this momentum and in so doing receives a torque proportional to the mass rate of flow. Torque is transmitted to gyro as rotation which in turn is transferred to register for mass flow total

POWER ENGINEERING'S

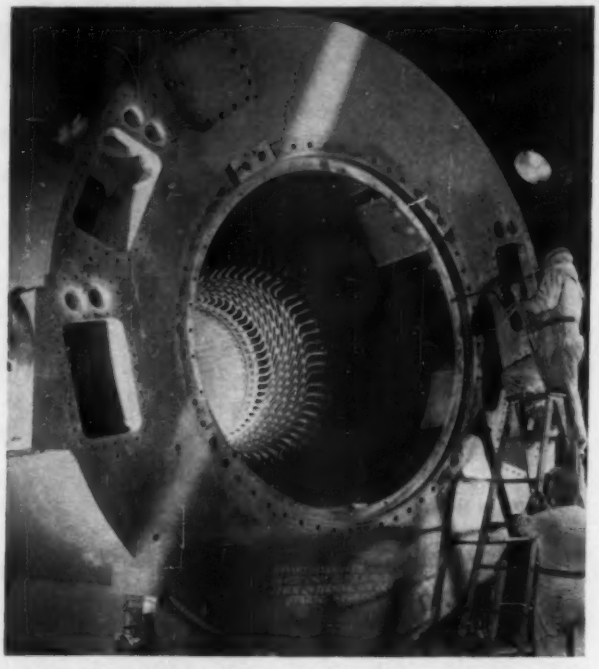
Stainless steel volute for canned motor pump being made by Westinghouse for Yankee Atomic Electric Co's nuclear power plant at Rowe, Mass. Unit will circulate radioactive water at 496 F at rate of 23,700 gpm at system pressure of about 2000 psi



1720-lb magnet, said to be the world's largest single permanent magnet, will help pump liquid sodium for the breeder reactor which Argonne National Laboratory will operate at a site near Idaho Falls, Idaho. Made by Arnold Engineering Co of Allegheny Ludlum Steel, dimensions are 52½ by 36 by 10 in.

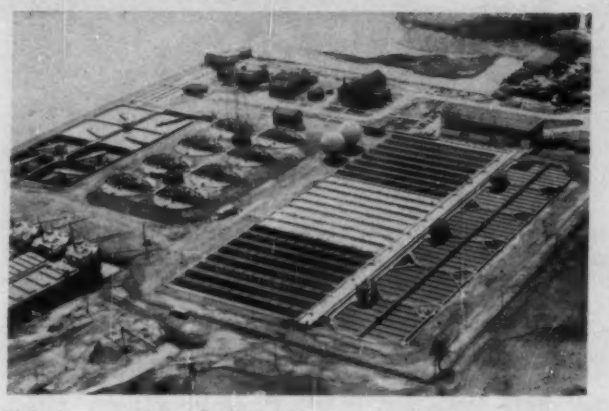


First of powerful new 1000-mva interrupting capacity units in 13,800-v line of air magnetic circuit breakers, made by I-T-E Circuit Breaker Co for Con Ed of New York. Here, in I-T-E testing lab, breaker arc chute is being tilted on rear pivot for easy check

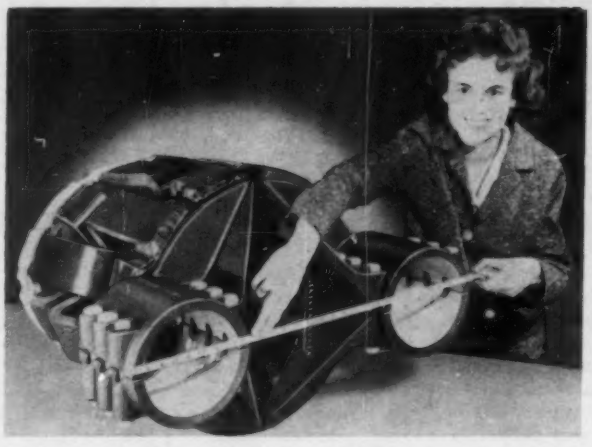


Stator for 100-mw steam turbine generator which will be unit No. 1 in Wisconsin Power & Light Co's new Nelson Dewey station at Cassville. Here stator gets final assembly in Allis-Chalmers shops. The tandem-compound double-flow turbine utilizes 1450 psig, 1000-F throttle steam, single reheat to 1000

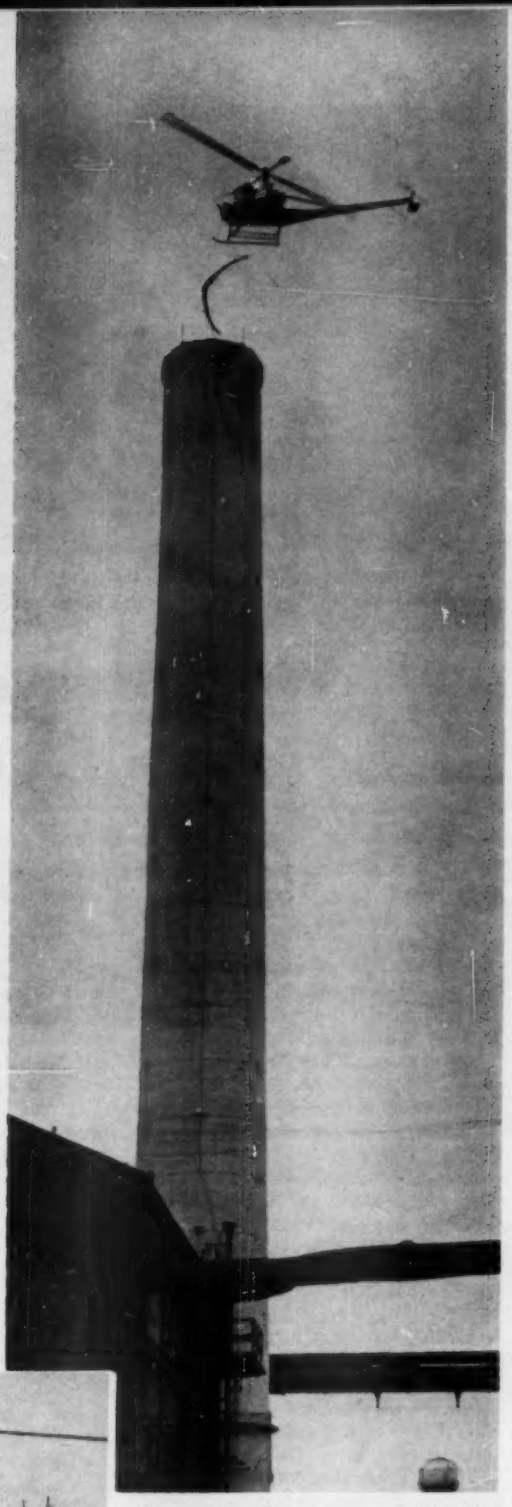
NEWS REEL



Toledo has added $9,500,000 secondary sewage treatment facilities (right in photo) to its sewage plant. Extended plant is of the activated sludge type, will enable the city to remove about 85 per cent of pollutional material in the collected wastes. Plant can handle complete treatment flows up to 70 million gpd



28 in. in length and 28 in. across the two terminal gaps makes the largest all-aluminum flexible connectors for an 11,000-amp, 19-in.-diam tubular aluminum bus. Units were made by H. K. Porter Co for highest ampere generator bus installation. There's minimum of current interchange surfaces



Copter to the rescue. 75-lb steel band came loose on rim of 170-ft chimney of power plant at Charmin Paper Products Co in Green Bay, Wisc. There it dangled, endangering life and limb. Call to sheriff brought Hiller Aircraft whirly-bird to the scene. Armed with a flexible ¼-in. steel cable, pilot lassoed the steel band as the copter hovered over the stack, brought band safely down in 10-minute operation

Fig. 1. Workman is shown checking newly installed stainless condenser tubes at Monongahela Power's Rivesville Station

Fig. 2. Another view of Rivesville condenser during retubing. For the first time, entire condenser is tubed with stainless

What Stainless Condenser Tubes Do At Monongahela Power

Designers have long hesitated to use stainless steel condenser tubes because of theoretical low thermal conductivity. This article tells how one company's experiences disproved that theory

FOR MANY YEARS, copper-base alloys have been an almost unanimous choice for tubing in main surface condensers, for a variety of good reasons. These alloys have a very good heat transfer rate, and even the more expensive alloys, such as cupro-nickel and aluminum-brass, are relatively low in cost. Besides, operating characteristics of copper-base alloys are known for almost any kind of water condition.

Even where stainless steel would be considered for a condenser tube application because of a corrosive environment, designers have hesitated to use stainless alloys because of their theoretical low thermal conductivity and higher cost.

In recent years, some very successful power plant installations have been made, using stainless steel condenser tubes, because of pioneering work on the part of tubing manufacturers, who have spent considerable time and effort in getting a more realistic appraisal of stainless in actual service. Such an installation is the Rivesville Station of Monongahela Power Co.

Because of acid mine waters, which were used as a cooling source for the main surface condensers at this station, severe corrosion problems had been experienced with 88–10–2 copper tubes. In one 55,000-sq-ft condenser, the corrosive environment was so severe that this copper-base alloy tubing material had to be completely replaced after less then seven years of service.

It had also been observed over a period of several years that the average cleanliness condition of all the main condensers at this station was consistently lower than the 85 per cent level customarily employed in sizing steam surface condensers.

In March, 1956, one of these condensers was retubed, and a week-to-week record of its cleanliness level was kept. This data indicated that the tubes retained a high degree of cleanliness for approximately 30 days after installation. Then the cleanliness level started to drop until it reached the 55 to 60 per cent clean range. Periodic cleaning of tubes in this unit with nylon brushes failed to restore the cleanliness factor to a value above 60 per cent.

In an effort to determine the reason why cleanliness factor of this unit

Table I shows the test results obtained with the stainless tubes at Rivesville

Date of Test	Type 304 Stainless Steel Tubes, ⅞ in. by 22 BWG		Required Cleanliness of Copper (88–10–2, ⅞ in. by 16 BWG) to produce same vacuum
	Expected	Actual	
July 24	.85	1.093	.666
July 28	.85	1.174	.715
Aug 7	.85	1.175	.716
Aug 14	.85	1.201	.731
Aug 19	.85	1.238	.754
Aug 27	.85	.915	.557
Sept 3	.85	.945	.576
Sept 10	.85	.811	.494
Oct 2*	.85	1.231	.750
Oct 3	.85	1.207	.735

* Tubes cleaned with nylon bristle brushes

Notes: 1. 9234 PGS Type 304 Stainless Steel tubes installed Sept 18.
2. Water velocity—6.5 ft per sec for Stainless Steel Tubes
7.0 ft per sec for Copper Base Alloy Tubes
3. Maximum cleanliness attained with Copper Base Alloy tubes is .60

Fig. 3. Tubes are expected to last 30 years. Former expectancy was 10 years

remained low despite extensive cleaning efforts, several tubes were removed from it in November, 1957 for investigation. One of those removed was a copper-base tube that had been installed during the March, 1956 retubing job. Another was a Type 304 stainless tube which had been installed in 1950 in order to combat ammonia corrosion in the air-cooling section of the condenser.

Both of these tubes were cleaned in the normal manner with nylon brushes before removal. Brushes were sized for the smaller 16-BWG copper tubes rather than the 18-BWG stainless steel tubes. Consequently, a relatively thick coating of mud was left on the inside of the stainless steel tube, compared to a thin, spotty film of mud on the copper tube.

Mud Flaked Off Easily

Mud coating on the stainless steel tube flaked off easily, however, exposing smooth bare metal. The thinner mud film would also flake off the copper tube, but underneath was a rough surface coated with a tenacious layer of corrosive products. Outside surface of the stainless tube was reasonably bright, while the outer surface of the copper tube was coated with a dense black film.

If cleaning methods more compatible with stainless tubing had been used, it would have been possible to remove almost completely the mud film in these tubes. However, had these harsher methods of cleaning been used on copper tubing, they would have exposed a bare metal tube surface particularly susceptible to rapid attack from the acid river water. Therefore, any benefits gained from the increase in heat transmission would be cancelled out by the decrease in tube life.

Based on experience to date, and examination of 18 BWG stainless steel tubing which was in service for over seven years, as well as a copper-base alloy tubing which was in service for approximately 18 months, Monongahela Power Co estimates that the copper base alloy tubing would have a life of only seven years, whereas 20-BWG Type 304 stainless steel tubing life expectancy would be in excess of 30 years.

As a result of this investigation, Monongahela Power Co retubed a 55,000-sq-ft condenser with Type 304, 22-BWG stainless steel tubes in June of 1958. In order to determine over-all efficiency of the stainless steel condenser tubes, ten tests were conducted on this condenser between July 24 and Oct 3 of that year.

High Cleanliness Factor

Information contained in Table I was obtained from these tests. From previous study, Monongahela Power expected a cleanliness factor on the Type 304 stainless steel of approximately 85 per cent. Under actual operating conditions, however, cleanliness factor on this alloy was as high as 1.238 per cent.

Lowest value reached during this test period was 0.811, which occurred just prior to cleaning. When the tubes were cleaned with nylon bristle brushes on Oct 2, 1958, actual cleanliness factor went up to 1.231.

Required cleanliness factor of copper-base tubing to produce a vacuum on the condenser equivalent to that obtained with stainless steel tubes is shown in the third column of figures. Based on previous experience obtained with this material, however, Monongahela Power Co states that the best cleanliness they could expect with copper-base tubes is 60 per cent.

Using this cleanliness factor as a base, the only time a condenser tubed with copper-base alloys would produce a higher vacuum than a stainless steel unit would be on Aug 27, Sept 3, and Sept 10, which were tests run just prior to tube cleaning. In these tests, actual water velocity through stainless tubes was 6.5 ft per sec, while an estimated value of 7 ft per sec was used in calculations for the copper-base alloy. If these velocity values were the same, the stainless steel tube condenser would have produced a better condenser vacuum.

Better Vacuum

When the stainless steel tubes were at a maximum cleanliness on Aug 19, the exhaust pressure at standard reference load was 2.13 in. of mercury absolute. A copper tube with a 60 per cent cleanliness factor under the same water conditions would provide a back pressure of approximately 2.65 in. of mercury absolute. Therefore, the stainless steel tubes at that time were capable of a 0.52 in. better vacuum at the reference load of 566,000 lbs per hr of condensate and a cold water flow of 49,330 gpm through the stainless steel tubes.

Visual inspection of the inside tube surface after cleaning with nylon bristle brushes disclosed that not all of the mud and slime had been removed. However, the mud had dried to loose, powder-like deposits appearing mostly on the bottom of the tubes where water had accumulated and finally evaporated. It is expected that most of this mud would probably wash out shortly after the condenser was returned to service.

By comparison, 10 copper-base alloy tubes, installed with the stainless steel for special study, were found to have already acquired a tight film of corrosion products. They retained considerably more of the mud and slime after cleaning than did the stainless steel tubes, and it appears they would be much more difficult to clean to the same cleanliness level.

Thus far, Type 304-22-BWG stainless steel tubes are performing much better than had been estimated in the preliminary report used to justify their purchase. If the recovery after cleaning remains comparable to that accomplished by the first required effort, there is little doubt that Monongahela Power Co will average up to one-half inch better vacuum with the condenser tubed with stainless steel tubes than they did when this unit was tubed with a copper-base alloy. THE END

Table II is a cost analysis for stainless steel tubes versus all the other alloy tubes

Material	16 BWG	17 BWG	18 BWG	20 BWG	22 BWG	24 BWG
Admiralty Metal	.3808	.3481	.2993	—	—	—
Arsenical Copper	.4269	.3898	.3352	—	—	—
Aluminum Brass	.4404	.4019	.3453	—	—	—
Muntz Metal	.3904	.3567	.5063	—	—	—
Aluminum Bronze	.4872	.4431	.3813	—	—	—
90–10 Copper Nickel	.5029	.4589	.3941	—	—	—
70–30 Copper Nickel	.6000	.5457	.4681	—	—	—
Type 304 Stainless	—	—	—	.6600	.5800	.5200
Type 7-Mo Stainless	—	—	—	.7500	.6500	.5700
Type 316 Stainless	—	—	—	.8000	.7000	.6000

Inflator (above, left) is used to find cracks or cuts in gloves. Glove is slipped on over moveable ring, which is raised or lowered by handle. Lower position clamps the glove securely. Air regulator controls air pressure at 15 psi. All gloves showing weather cracks or cuts are scrapped. Inflator is made by White Rubber Co.

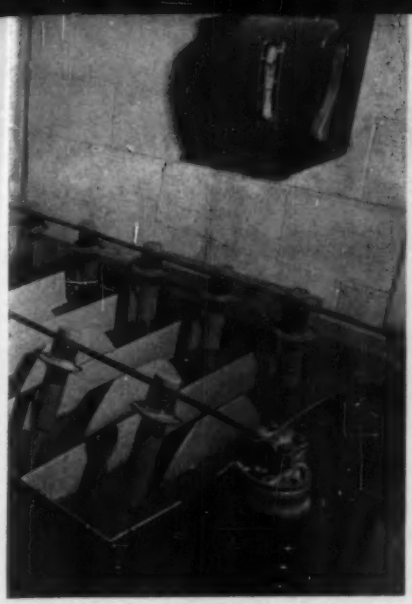
Clever racks for handling gloves, sleeves and blankets were made in company's Testing Lab. So were the tables which hold jumpers and also blankets. All are on coasters for full mobility.

Powdering drum was rigged up by the company's Testing Lab from a fiber drum 30 in. high and 20 in. in diam. Copper plate was fastened to each end and drilled for a ½-in. rod. Drum rotates on the rod by a small electric motor at 20 rpm. Drum will powder 12 gloves or 10 sleeves at a time. Total system demand for protective items is as follows: gloves, 1467 pairs; sleeves, 770 pairs; blankets, 1175; standard mechanical jumpers, 810; pickup mechanical jumpers, 276. A stock of 40 per cent over the total demand is carried for items tested every three months; a stock of 25 per cent over the total demand, for equipment tested every six months.

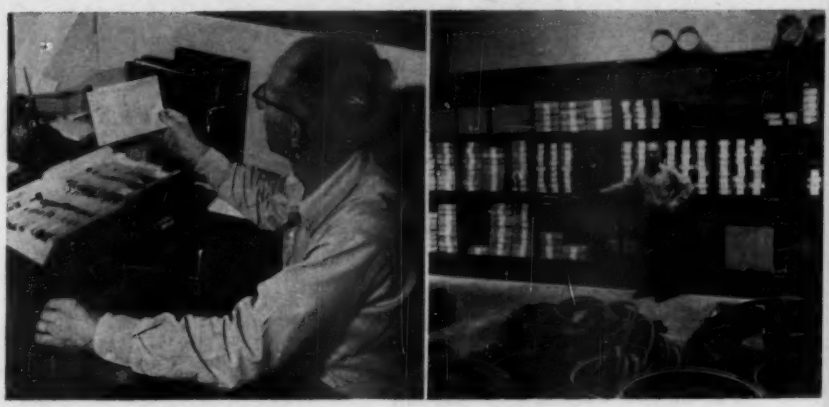
In boxing rubber sleeves a cardboard form is inserted in sleeve before it is slipped into container. Linemen keep sleeves on these forms when not in use in the field. When shipments are made from headquarters, two forms accompany the equipment. One form is returned with the exchanged equipment, for recording the number of pieces returned. Received at Plainfield, the equipment is counted, inspected, stored, or discarded as flaws are found.

Finding the Flaws

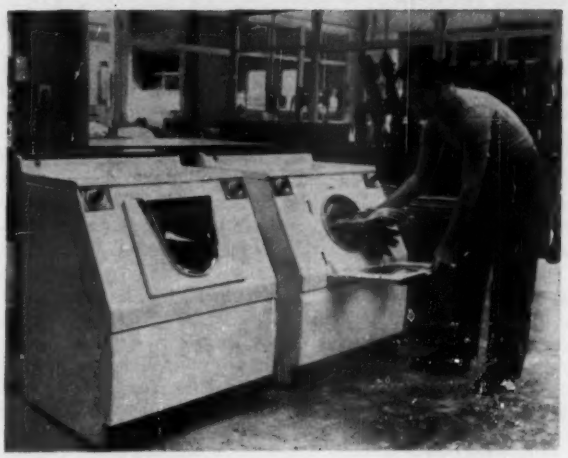
How Public Service Co of Indiana makes sure of that all-important equipment which can mean life or death to the linemen. Over the years, the company has developed a model procedure for testing the protective equipment used throughout the system. Rubber gloves and sleeves are tested every three months; rubber blankets and mechanical jumpers, every six months. All testing is done at the company's headquarters in Plainfield, Ind. These photos tell the story



▲ **Floyd Godby,** protective materials tester, puts a batch of mechanical jumpers through 20,000-v test for three minutes. Before test, jumpers are torn down and completely rebuilt. Test tank, used also for blankets, was made locally to specifications. It is 48 in. long, 36 in. wide, 42 in. deep, gets voltage from the Hanco Tester (bottom, right). High voltage throw-over switch does the trick.

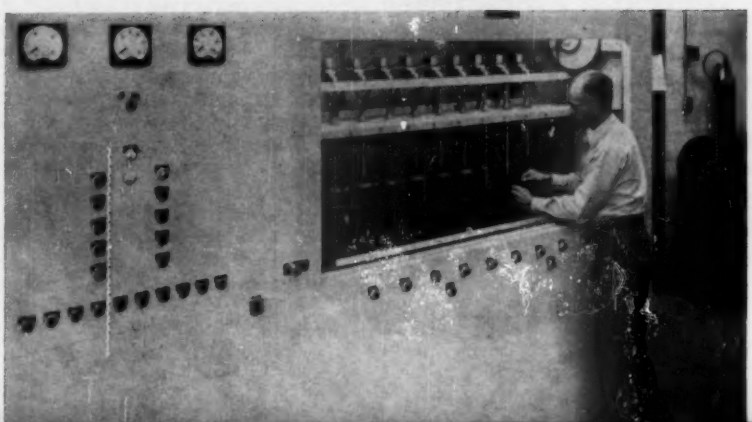


Card system, 5 by 8 in., is used to ▶ keep record on each kind of protective equipment sent to and received from 55 locations over the system. Demands of each location are recorded on back of cards. There is a card for each month showing which locations will get equipment. In storage room (right) boxes sealed and ready to ship hold rubber gloves and sleeves. Mechanical jumpers and rubber blankets are shipped in fiber drums.



Washing and drying of rubber gloves received from the field is done in Westinghouse automatic washer and dryer presided over here by Vernon Lashbrook. All rubber equipment is washed and dried before testing. Company vans carry protective equipment to and from 55 locations over the system. The vans make four routes every two weeks. This gives the field two weeks in which to make exchanges of equipment.

10-glove and sleeve Hanco Tester is fully automatic. Gloves are tested at 20,000 v for one minute, sleeves at 10,000 v for one minute. When glove or sleeve fails, the Tester locks out, and an overload relay trips the machine. If the operator does not notice which piece failed, he will set the Tester on manual operation and slowly bring up voltage until failure is located.



Forced Aeration of Streams by

Introduction of air into the water through power turbines, to bolster the natural purification processes of the stream by restoring disrupted DO balances, is advocated, though some loss in turbine operating efficiency is involved. Wisconsin experiments show the way

By BERNARD F. LUECK * and RALPH H. SCOTT †

IN MANY localized areas throughout the country, population and industrial concentrations have provided quantities and volumes of sanitary and industrial wastes exceeding the capacity of presently available treatment facilities. In other areas, these wastes, even though efficiently treated, yet carry a residual loading of organic material to the stream which surpasses the natural purification capacity of the receiving waters.

Stream pollution control authorities on the local, state, and Federal level are constantly concerned with the application of all known methods of pollution abatement to correct these conditions of water pollution. Separate industries, or industrial groups, are well aware of their responsibilities in this endeavor and are spending large sums for waste treatment, or on research eventually leading to adequate stream pollution prevention. Many industrial wastes may be now adequately treated by presently known methods. The treatment of others yet awaits a satisfactory solution through continued research, either to improve the degree of treatment efficiency, or to develop treatment methods compatible with the economic requirements of the particular situation.

When natural and man-made wastes enter a stream or body of water, certain microbiological reactions take place which tend to disrupt the natural dissolved oxygen balances in waters. Fish and other smaller animal life in the water require this dissolved oxygen to sustain life. Nature has several means at her disposal to destroy these wastes and restore the balances. However, she is sometimes overwhelmed, and polluted or semi-polluted water may result.

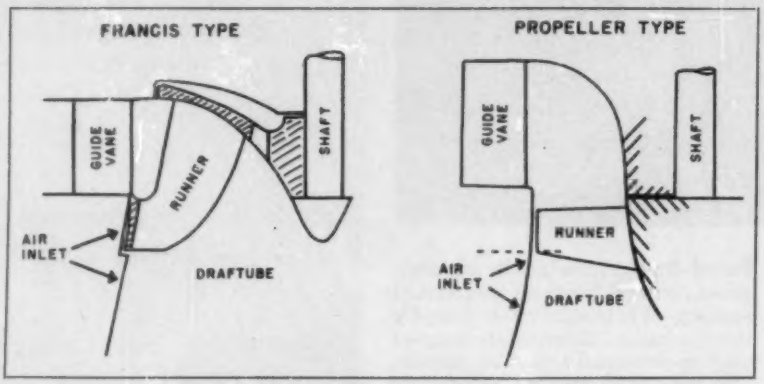
The natural purification of streams is time and temperature dependent. When waters become warm, bacterial action is increased, demanding more oxygen at a time when the rate of atmospheric oxygen solution is decreased. As a result many streams that can tolerate and oxidize a given load during nine or ten months of the year become unbalanced during the hot two or three months of the summer. Because of ice coverage and lack of surface reaeration, other streams become devoid of oxygen during only the winter months. Large impounded volumes of water become oxygen deficient in deep water due to temperature stratification.

It is to alleviate these temporary conditions that forced aeration is advocated. Introduction of air into the water through power turbines has proved a successful and relatively cheap means of doing this. Over the past several years considerable data concerning this type of aeration have been obtained on several Wisconsin rivers.

Both Francis- and propeller-type runners were utilized in the experimental work. Francis-type turbines were vented either by admission of air to the draft chest, or by venting behind the runner ring. Propeller-type units were all vented to the draft chest. In all of these installations, some of which were installed as original equipment, the air line was led from the point of admission, through the open flume, to the outside, where a valve was installed to control air admission rates.

At Little Rapids on the Fox River, the runners were at tail water level. As no vacuum exists under these conditions, air was forced to the runner outlet by a compressor during the experimental work. Results here were inconclusive, but further investigation is underway to determine the feasibility of forcing air to such an installation.

Typical points for air admission are shown in the sketch. Vents installed varied from four 1½-in. ID pipes, evenly spaced around the runner ring, to two 4-in. ID pipes leading to opposite sides of the draft tube of propeller-type turbines.



Typical points for air admission to the turbine. Air line is led from point of admission through open flume to the outside where a valve controls the rate of air admission

Why This Article

Evaluation of the data obtained from operation of vented turbines at six locations on Wisconsin rivers during 1958 shows that this method of introducing oxygen to the waters of a flowing stream represents one of the first practical ways in which critical levels of low dissolved oxygen may be substantially alleviated. Thus stream pollution control under certain conditions has won a new and relatively inexpensive tool.

Results of Turbine Aeration

Wisconsin Committee on Water Pollution and Sulphite Pulp Manufacturers' Research League have, for a number of years, been concerned with joint investigations of major

* Chief chemist, Sulphite Pulp Manufacturers' Research League, Appleton, Wis. † Public Health Engineer, Wisconsin Committee on Water Pollution, Madison, Wis. This article is based on data the authors presented at the 14th Annual Purdue Industrial Waste Conference

Hydro-Turbine Proves Practical

Table I. Descriptive data on turbines and power loss characteristics. Actual loss is substantially smaller than observed loss

River and (Location)	Flow cfs: 50% of Time	Flow cfs: Aver. through test turbines	Type of Unit	Size Kw	Head Ft	Pounds O_2 Gain Per Kwh Loss: Observed	Pounds O_2 Gain Per Kwh Loss: Calc.	Observed Power Loss Per Cent
Flambeau (Pixley)	609	407	Horizontal Double Runner, Francis	600	21.6	2.50	3.68	10.6
Wisconsin (Hat Rapids)	950	338	Horizontal Multiple, Francis	320	20.0	1.82	5.64	7.1
Wisconsin (Rothschild)	2420	1762	Horizontal Multiple, Francis	800	20.0	5.43	—	2.5 (Estimated)
Lower Fox (Kimberly)	3610	1219	Vertical, Variable Pitch, Propeller	900	9.0	3.30	—	6.0
Lower Fox (Rapide Croche)	3610	1043	Vertical, Variable Pitch, Propeller	800	8.0	3.20	3.93	10.1
Lower Fox (Little Rapids)	3610	748	Vertical, Francis	185	7.0	—	—	—

Table II. Summary of dissolved oxygen data for turbine aeration. Addition of 10,000 lb per 1000 cfs may be possible

River and (Location)	Max. Temp. C	No. of Analytical Runs	DO Before Aeration ppm	DO After Aeration ppm	DO Gain ppm	Aver. O_2 Absorption Efficiency %	O_2 Absorbed lb/1000 cfs/day
Flambeau (Pixley)	23	20[1]	0.71	2.22	1.51	25.7	7800
Wisconsin (Hat Rapids)	20	1[2]	0.58	2.07	1.49	15.2	8200
Wisconsin (Rothschild)	26	Weekly	2.46	3.84	1.38	—	5920
Lower Fox (Kimberly)	25	7 Weeks	0.93	1.28	0.35	22.0	1890
Lower Fox (Rapide Croche)	25	Daily	0.30	1.40	1.10	21.0	6150
Lower Fox (Little Rapids)	22	3	0.26	0.55	0.29	56.0	1600

[1] Five additional detailed analytical runs made without aeration for comparison.
[2] Best of 9 runs to develop optimum aeration conditions.

rivers in Wisconsin. A portion of the field investigation completed during 1957 was devoted to examining the merits of aeration of streams by admission of air to hydro-turbines at Pixley Dam on the Flambeau River. During 1958, the groups carried out additional investigations at this point, and also at Rapide Croche Dam and Little Rapids Dam on the Fox River.

In addition, the results obtained from turbine reaeration projects operated by members of the pulp and paper industry in the state have been made available.

On the Wisconsin River at Hat Rapids Dam, Rhinelander Paper Co conducted experimental work in collaboration with the Wisconsin Public Service Corp, owners of the dam. Also, on the Wisconsin River, the Marathon Corp, a division of American Can Co, completed the second full summer of aeration at Rothschild. On the Fox River, the Kimberly-Clark Corp continued aeration of the stream at Kimberly for the second summer. Preliminary investigations by the coöperating groups at Rapide Croche Dam on the Fox River resulted in a four-week sustained test of the reaeration possibilities at this site by the Thilmany Pulp and Paper Co, Kaukauna. This work was carried out in collaboration with the City of Kaukauna Electric and Water Utility, operator of the dam. Data regarding test units employed and power loss characteristics for the turbines tested are shown in Table I.

While the cost of installing venting means of this type is moderate, and maintenance costs non-existent, the effect of reduced suction head will be of concern to those responsible for hydro-plant operation.

Cost of introducing oxygen by turbine aeration results from losses in turbine operating efficiency, and perhaps chiefly from the loss in effective through-put of water for power production purposes due to loss of suction head. The turbine, therefore, loses a portion of its power-producing capacity. Gain in oxygen per observed kwh lost was calculated in the first five of the six studies carried out in 1958, and ranged from a low of 1.82 lb to a high of 5.43 lb of oxygen.

These observations of the apparent losses were obtained from reading of panel meters on the generators. However, hydraulic engineering authorities who have studied these data are well agreed that the actual loss is without doubt substantially smaller than the observed losses of power production.

In at least two of the turbine aeration studies reported in Table I, attempts were made by the engineers to estimate correction factors which might apply. For the Flambeau River it was estimated that the actual amount of oxygen gain per kwh lost was increased from 2.50 to 3.68 lb, or a corrective factor of about 33 per cent. Similar calculations made for the tests at Hat Rapids on the Wisconsin River indicated that the pounds of oxygen gained per kwh lost was increased from 1.82 to 5.64 lb. These latter data showed the true

loss in power production potential to be only one-third of the apparent loss.

These questions, concerned with the amount of true power lost by a turbine and the cost of introducing a given amount of oxygen, remain as problems to be further developed by later engineering studies. There seems little doubt that the costs and the loss of power production are quite reasonable for the amount of work accomplished, but in spite of extensive discussion of the engineering theory and practice with representatives of principal manufacturers of turbine equipment, consulting engineers, and university research authorities, it has proved difficult to formulate a reliable and common basis which could be employed for calculating these costs and losses. Each of the power dams and turbines under study have been sufficiently different in design and operating characteristics as to make necessary individual studies of each location.

Table II shows the results obtained from the turbine aeration sites studied. Gains in dissolved oxygen concentration on the Flambeau and at Hat Rapids on the Wisconsin River were on the order of 1.5 ppm. At Rothschild the dissolved oxygen level in the aerated water was raised 1.38 ppm to an average level of 3.84 ppm. Dissolved oxygen data on the Fox River showed increases of 0.35 ppm at Kimberly and 1.35 ppm and 1.1 ppm at Rapide Croche. An average figure of 25.7 per cent for oxygen absorption efficiency was obtained from the 20 carefully conducted aeration runs at Pixley Dam on the Flambeau River.

Actually, absorption efficiencies on several individual runs exceeded the average considerably, and one of these tests ranged to 34.9 per cent at that location. At Hat Rapids the absorption efficiency was shown to be 15.2 per cent, the Kimberly run on the Lower Fox River 22 per cent, Rapide Croche 21 per cent, and as high as 56 per cent was obtained in one of the preliminary runs conducted at Little Rapids on the Fox River.

From these data it seems quite probable that further development of equipment design and operation techniques may eventually permit obtaining oxygen absorption efficiencies in the range of 25 to 35 per cent or a possible oxygen addition rate of around 10,000 lb per 1000 cfs. The usually accepted oxygen exchange rate for diffused air aeration is around 6–8 per cent absorption efficiency.

Use of turbine aeration appears especially valuable for periods of hot summer weather, when stream flows are low and the waste concentrations in the stream higher than normal. It is true that the opportunities to take advantage of turbine aeration are usually limited by the fortunate location of those power dam installations which happen to be available in the areas of critical low dissolved oxygen concentration in the stream. Turbine aeration has to be utilized where the stream is running low in dissolved oxygen content, on the order of 40 per cent oxygen saturation or less. Such reaches are found some distances downstream from the principal sources of pollution. THE END

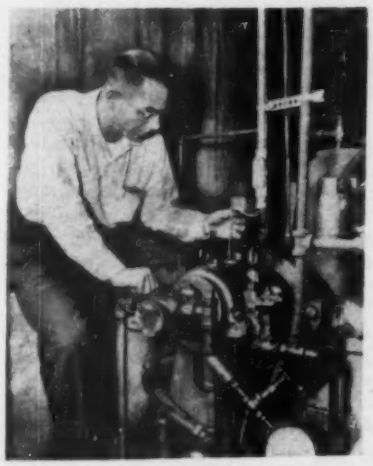
Overheat Sensors Protect Bearings in Auxiliaries

A COMPREHENSIVE thermistor monitoring system for detecting incipient bearing damage in auxiliary powerhouse equipment is paying off at the Buffalo, N. Y., plant of National Aniline Division, Allied Chemical Corp.

Developed by Fenwal, Inc, the overheat detection system covers a total of 84 points in two power plants and a river-water pumping station. The protected equipment includes all forced-draft fans, induced-draft fans, boiler feed pumps and feedwater transfer pumps associated with five large-capacity steam boilers, plus four river-water pumps which handle up to 20 mgd of cooling water.

The detection system solves the problem of providing around-the-clock protection of essential equipment, which is widely scattered at many unmanned locations in three plant areas. Total savings in cooling water, lubricating oil, and manpower resulting from this installation should amount to about $40,000 annually, according to the estimate of H. W. Busch, engineering manager.

With the traditional palm-of-the-hand method, by the time the surface of a 3–5-in. thick bearing housing feels abnormally hot to the touch, the bearing is generally beyond saving. But with the thermistor sensor in actual contact with the bearing, potential trouble is detected as it develops, not after it has occurred.



Thermistor detector installed in bearing housing of feedwater pump. Warnings show on combustion control panel

System consists of 84 thermistor detection units wired to an alarm system. Each detection unit is set to actuate when the bearing temperature rises to 30 F above the normal summer operating temperature.

Bearings in all boiler fans and feedwater pumps and associated motor drives, as well as in the river water pumps, are protected with thermistor probes — a total of four points in a typical driven unit and driver. In motor-driven equipment having a speed reducer or speed increaser, a low-pressure lube oil switch is installed in the gear box lubrication line and is incorporated into the alarm system with the thermistors.

The leads from each group of probes are connected to amplifier units 40–75 ft away, which actuate the alarm circuit when an overtemperature condition occurs. The alarm temperature for each bearing is individually adjustable. Alarm consists of a warning light plus a distinctive horn signal tied in with the building's emergency annunciator system. All indicator lights are installed on the firing floors, which are always manned.

The 3/16-in.-diam stainless steel thermistor probe is installed by means of a compression-type fitting in a hole drilled into the bearing housing. National Aniline has standardized on a 6-in.-long probe for all bearings. Mounting hole is drilled so that tip of the probe rests against the outer race of ball bearings or the babbitt backing of the sleeve bearings.

Fig. 1. Power for a 20-hp electric motor to drive this tractor is provided by the bank of 1008 fuel cells shown here

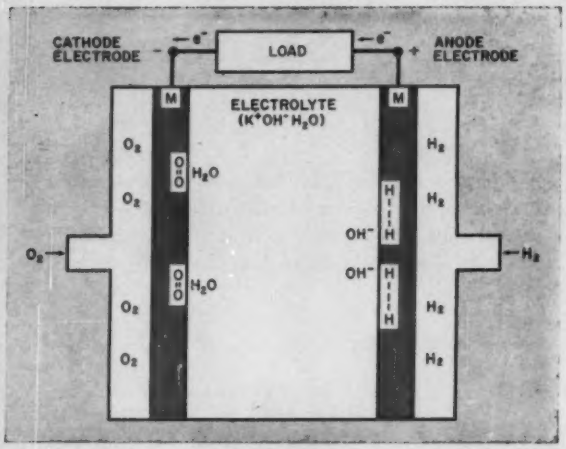


Fig. 2. Diagram of fuel cell used in recent demonstration shows how chemical energy is converted to electric energy

Feasibility of Fuel Cells Dramatized At Allis-Chalmers Demonstration

Electricity must be generated as needed. Under present state of the art, it cannot be stored. Fuel cells may change that picture

FEASIBILITY of fuel cells as a source of electrical energy has been dramatically demonstrated by Allis-Chalmers Manufacturing Co. The tractor shown in Fig. 1, powered by a 20-hp electric motor mounted on the rear axle and using direct current generated by a bank of 1008 fuel cells, was recently shown to a group of scientists and engineers in Milwaukee.

Direct conversion of the chemical energy of gases into electricity is rapidly emerging from the category of a laboratory curiosity into the realm of practicality (see POWER ENGINEERING for Nov, 1957). Fuel cells are similar in many ways to storage batteries, but have advantages that are superior in many respects. Both consist essentially of electrodes and an electrolyte. Whereas conventional storage cells have their energy stored in the system within the cell, the fuel cell can store no energy within the cell but must instantaneously convert chemical energy to electrical energy as the latter is required.

Figure 2 is a diagram of the Allis-Chalmers fuel cell used to power the tractor in Fig. 1. As shown in the diagram, hydrogen gas is adsorbed onto the catalyst at the anode electrode and reacts with an ion in the electrolyte (potassium hydroxide in this case) to form water. This reaction releases an electron to the external circuit. At the cathode electrode, oxygen is adsorbed and activated, causing it to react with an electron from the external circuit and with the electrolyte to reform the ion which disappeared at the anode.

Over-all reaction is the disappearance of hydrogen and oxygen to yield water and produce a flow of electrons. Those electrons flowing through the load are forced to do so before the chemical reaction is complete. Thus, all the electric energy delivered by the cell is converted chemical energy.

Production of electricity directly from hydrogen and oxygen in the fuel cells is significantly more efficient than its production in a conventional steam system, in which the steam is supplied by burning these same gases. Heat losses inherent in the conventional steam system reduce the over-all efficiency of that system to about 35 per cent. A fuel cell, on the other hand, eliminates the intermediate heat step and converts directly from chemical to electrical energy with a top efficiency of approximately twice that figure. Actually, there is no theoretical limitation on efficiency. Some authorities have mentioned efficiencies as high as 90 per cent as being perfectly feasible.

Operation of fuel cells at normal operating temperatures (from 120 to 140 F) will, as a rule, result in efficiencies of from 65 to 80 per cent. Laboratory studies indicate that the optimum fuel cell design eventually will be one that will produce approximately one kw of power from a package unit one cu ft in volume.

As a practical producer of electrical energy, fuel cells such as those powering the tractor shown in Fig. 1 depend upon economical sources of hydrogen and oxygen, gases that at present are relatively expensive and require heavy pressure vessels for containment. Possible hydrogen sources include coal, which yields hydrogen when exposed to steam in the manufacture of water gas. Ammonia is another possible source. Catalytic cracking of petroleum products can also produce hydrogen.

Many engineers see the fuel cell as a valuable energy conversion method. Use of off-peak generator capacity for electrolytic process to produce hydrogen and oxygen which can be stored, transported, and used at will in fuel cells may well serve as an answer to the long search for a practical method of storing electric energy during off-peak periods. THE END

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Standardized Insulation Nets New Memphis Plant Big Savings

By looking at the K-factor and temperature range, Burns and Roe were able to select optimum conditions for the most economical use of thermal insulation at the Thos. H. Allen Electric Generating Plant in Memphis. This describes the result of their computations

By **MILTON H. ELLIS, JR.***

TODAY'S LARGE, high-temperature, high-pressure steam generators are complex pieces of equipment requiring care and precision in erection and maintenance. However, one way that they can be simplified for erection crews and operating and maintenance personnel is to standardize their construction as much as possible.

One phase of boiler construction which lends itself well to standardization is thermal insulation. More and more, the number and types of different materials used to prevent the loss of precious heat from an operating boiler are being reduced and their application methods simplified. The availability of economical and efficient insulating materials, which can be used over a wide range of service temperatures and adapted to a number of sound application techniques, have made this standardization possible for a number of individual boiler projects.

As an example of how simplification through standardization is being applied, take the insulation of the three 2,100,000-lb-per-hr boilers recently erected by The Babcock & Wilcox Co at the Thos. H. Allen Electric Generating Station for the Light, Gas & Water Division of the City of Memphis. The station's design permits expansion to double its present net capability of 812,500 kilowatts, as required by future loads of Memphis and Shelby County.

On each of these huge units, over 1,500,000 bd ft of spun mineral-wool block was used as the basic insulating material by the insulation contractor, the M. H. Ellis Co. The versatile block insulates all flat surfaces and all cylindrical surfaces, 30 in. or greater in diameter, up to a maximum temperature of 1200 F. For the few surfaces hotter than this, a calcined, diatomaceous earth insulating block is used as the first, or hot-side, insulation course, and then it is covered with mineral-wool block. Block thickness was specified to provide an average exterior surface temperature of 130 F, based on an 80-F ambient temperature and air velocity of 50 ft per min.

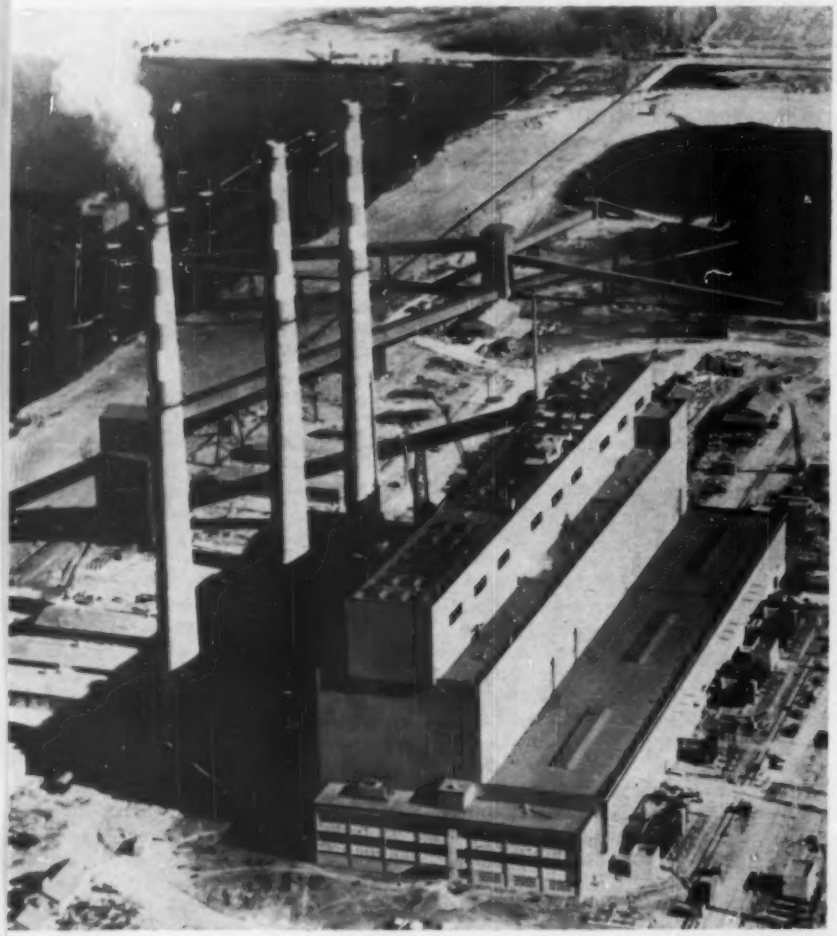


Fig. 1. Aerial view of the Memphis station just after the first unit went into operation. All three are now on line

Block Is Versatile

In addition to its excellent thermal efficiency and wide service temperature range, the block, called Mono-Block by its manufacturer, the Baldwin-Hill Co, is extremely versatile. Such mechanical characteristics as its light weight, which makes it easy to handle; its resilience, which helps it conform to curved or interrupted surfaces; and the ease with which it can be cut and shaped to fit irregular areas were all factors which tended to facilitate its application.

This use of one basic insulating material in a few appropriate standard sizes reduced the insulation contractor's inventory problems, and made standardization of application methods simpler. Only two basic attachment methods were required — one for flat and one for curved surfaces.

* President, The M. H. Ellis Co

Fig. 2. (Left) The wires in groups of four extend through the first layer of insulating block, ready to hold second

Fig. 3. (Above) After installation of second layer, wire is criss-crossed in diamond pattern, at least two per block

Importance of the resultant simplification can be readily imagined on a job the size of the Memphis installation. The largest municipal steam plant ever built at one time, this is one of the most highly publicized. The station has a rated capacity of 750,000 kw and an aggregate net capability of 812,500 kw. During the winter months it will burn coal, shipped in by Mississippi River barge, and during the summer the boilers may be fired by natural gas.

Simplification in boiler design and construction is also illustrated in the Memphis project by the Babcock & Wilcox practice of standardizing on just two insulation thicknesses for the saturated-pressure parts of the boiler, such as tubes, headers, and drums. Thickness is based on the steam pressure involved.

All sections carrying steam at pressures up to 1050 psi are insulated with a 3-in. thickness of medium-temperature insulation. Those carrying steam at greater pressures are protected with 4-in. medium-temperature insulation. This results, perhaps, in over-insulation of certain hot surfaces but is considered to sufficiently simplify application to be economically justified. Certainly it is sound practice from the standpoint of additional thermal efficiency.

On this job the basic insulation attachment method used, with only a few exceptions, on every flat surface throughout the huge Memphis boilers

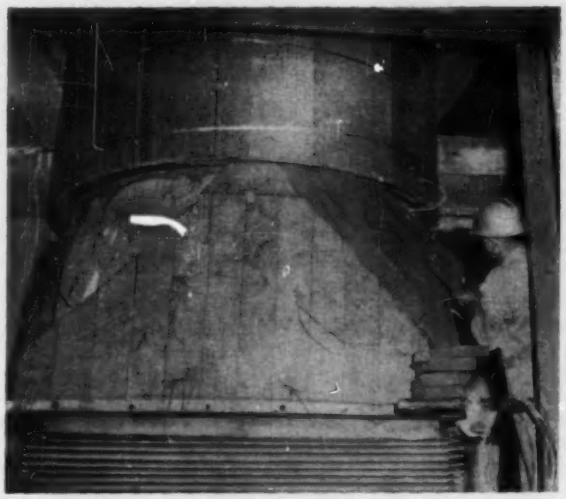


Fig. 4. Ease of handling is demonstrated as insulating block is cut to conform with either a curved or irregular surface

Fig. 5. Beveled edges, cut with small table saw, make tight-fitting coat for cylindrical surface of a 30-in. downcomer

Fig. 6. (Above) Insulating block wired directly to cyclone riser tubes simplifies tough job, cuts costs considerably

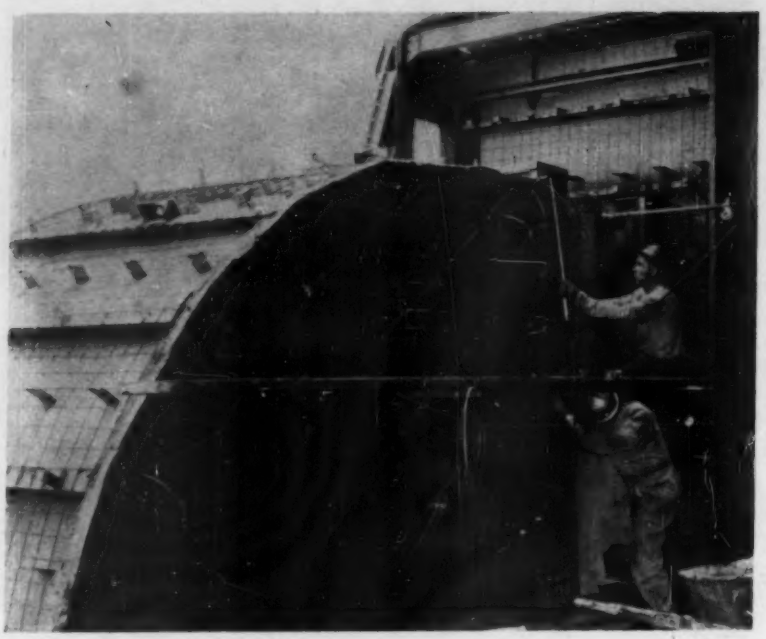


Fig. 7. Road mesh is welded to flanges and stiffeners on boiler flue recirculating outlet in preparation for installing two layers of insulating block

is illustrated in the photographs showing the application to the furnace wall. The pressurized boilers have a 10-ga steel inner casing to which ⅜-in. self-welding stud washers were welded in the shop. These washers, spaced at appropriate intervals on the exterior of the casing panels, served as anchor points for the 14-ga galvanized steel tie wires, which hold the insulation in place.

To secure the block insulation, two tie wires were looped through each stud washer, and both ends of each wire were brought through a hole over all four protruding wires; the wires were stretched over the surface of the insulation, tied, and twisted tight to adjacent lacing wires in a diamond pattern, Fig. 3. The washers prevent the wire from cutting into the block at the points where they emerge on the surface of the insulation. The studs welded to the casing were located so that each separate block was crossed by at least two wires.

When two layers of insulation were required, both were impaled upon the wires before the lacing wires were tied across the surface. Of course, when the two layers were applied, the joints between the blocks of the second layer were staggered with respect to those of the first layer.

Thickness of block insulation, applied to flues and ducts at the Thos. H. Allen Electric Generation Station, was determined by the maximum temperature of the gases carried, according to the schedule at the top of the next column.

Maximum Temperature, Degrees F	Block Thickness, Inches
350	1
450	1½
500	2
550	2½
600	3
700	3½
800	4
900	4½

Because of its resilience and workability, the mineral-wool block was also easy to install on the unit's cylindrical ducts. By making a bevel cut lengthwise through the block, Fig. 5, and then reversing one of the two pieces and butting the beveled edges, an approximate radius was formed. Depending on the diameter of the surface in question, curvature could be made to correspond very closely to that of the duct. The inherent resilience of the block did the rest, making a snug fit with the cylindrical surface.

At Memphis the lengths of beveled block were then held temporarily in place on the cylindrical surface with oversize "rubber bands," made from old inner tubes, until they could be permanently banded with ¾-in. steel bands and clips, Fig. 6. As on the flat surfaces, all joints and voids between blocks were then filled with B-H No. 1 Insulating Cement to complete the thermal seal, Fig. 7.

Method of applying the block to the rectangular flues and ducts differs from that used on the furnace wall only in the way in which the tie wires are anchored to the duct surface. Here, rather than securing the wires directly to the surface being insulated, they are anchored to a course of 4 by 4-in., 8-ga road mesh welded to the flanges and stiffeners, and bridging the gap between these projections, Fig. 8. Thus the block could be laid to give a smooth, flat outer surface with no special treatment required for covering the flanges or stiffeners to give the specified insulation thickness.

Because of its workability, Mono-Block could also be used, instead of molded pipe covering, to directly insulate various tube bundles. By wiring the block directly to the tubes themselves, a snug thermal barrier was created without the need for a special material.

Although the furnaces are housed, flues, air ducts, and the air preheater are located outside the building. In order to prevent accumulation of standing water, the insulation and its protective metal covering on the top horizontal surfaces are sloped downward, ¼ in. per ft, from the centerline of the duct. This is accomplished by sloping the road mesh base, to which the insulation is attached, when welding it to the duct. The standing seams in the metal lagging finish on these surfaces run parallel to the slope.

For maximum protection against moisture or accidental damage, as well as for an attractive finished appearance, all insulated surfaces are finished with metal lagging. The penthouse roof is lagged with 16-ga roof decking having 2½-in. ribs. Other surfaces are finished with either 18-ga flat sheet metal or the ribbed roofing. Lagging is secured to the clips which protrude the insulation. THE END

Scraper Rings—Design and Application

Rotating and reciprocating machines require many types of gaskets and packings. One of the most generally used types is the scraper ring, required on practically all reciprocating equipment. Here are elements of its design and application, as a maintenance guide

By DONALD E. KLEIN *

IN RECIPROCATING gas compressors and gas engines, liquids such as lubricant or condensate can be kept from areas of the equipment, where their presence is undesirable, by proper use of what are known generally as *scraper* or *wiper* rings. The most common application of such scraper rings is on the rods of reciprocating gas compressors.

In particular, the scraper rings are used to prevent oil which has been splashed onto the rod by the rotating compressor crankshaft from escaping the confines of the crankcase.

A typical application of scraper rings installed in a reciprocating compressor is shown in Fig. 1. In this example, as the crankshaft, (A), rotates, lubricant from the crankcase is splashed onto the rod, (B). As the rod moves on the upstroke, the scraper rings (C, see Fig. 5 also) remove the oil from the rod and collect it in the scraper gland, or case (D), and drain it through the oil port, back into the crankcase.

Reasons for removing the lubricant from the rod in the foregoing seem obvious. However, there are many less obvious reasons for requiring highly efficient scraping such as:

1. Simple saving of lubricant. If the lubricant is allowed to carry through into the cylinder, it will be carried away in the exhaust gases, and irretrievably lost, unless salvaged by expensive recovery systems.

2. Too much lubricant carried into the system can be deleterious to the action of rod packings and piston rings. Excess lubricant in a rod packing set can seriously reduce the efficiency of the packing set. If temperature conditions are sufficiently high, the lubricant can become carbonized, making the packing set inoperable.

3. In many modern compressor applications the presence of even minute quantities of lubricant, or other contaminant, in the compressed gas is intolerable. An efficient scraper set can (in most instances) control the quantity of lubricant allowed into the exhaust gas to within specified limits.

4. In many cases, fluids other than lubricants may be present, and can be harmful to certain operating components of reciprocating equipment. A typical example of this condition is in the control of condensate in a steam engine. Again, an efficient scraper set can closely regulate the leakage of the fluid.

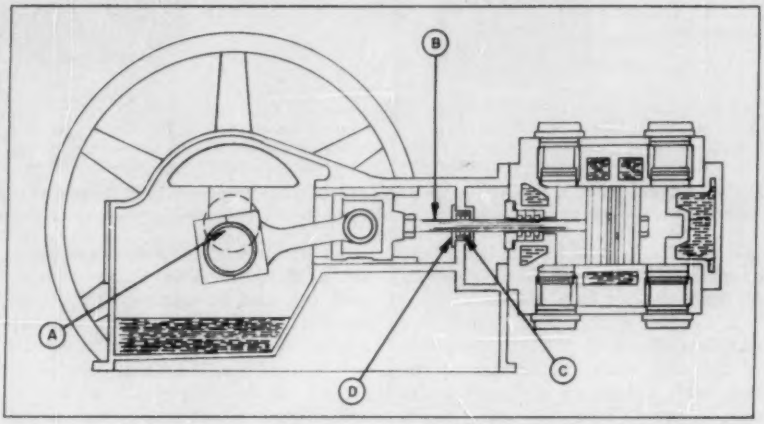


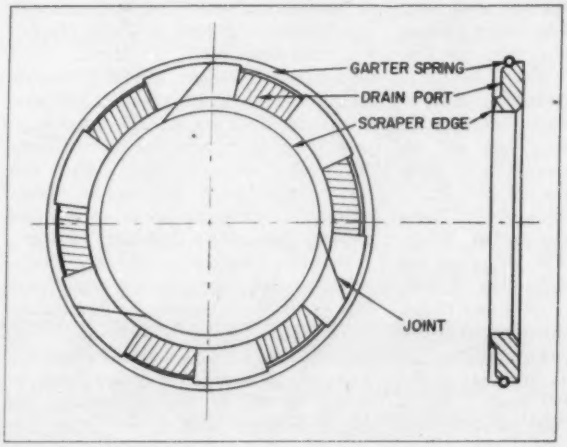
Fig. 1. Typical compressor cross-section, showing location of shaft scraper rings

Designers of scraper rings must consider three elements, each an important factor in operational effectiveness, when evolving basic ring configuration. Referring to Fig. 2:

1. Scraper edge — designed to remove fluid from the rod, and to impart a velocity to the fluid, which will carry it away from the rod.

2. Drain port — a relieved area in the flank of the ring, to allow drainage of the scraped fluid to the outer periphery of the ring. These ports

* Product Engineer, The Garlock Packing Co



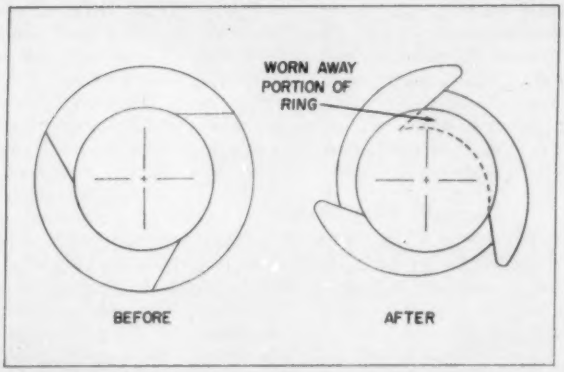


Fig. 2. (Left) Drawing of one type scraper ring, with principal details. Fig. 3. (Above) Unusual wear on shaft scraper rings results in this type of seal, which permits oil leakage

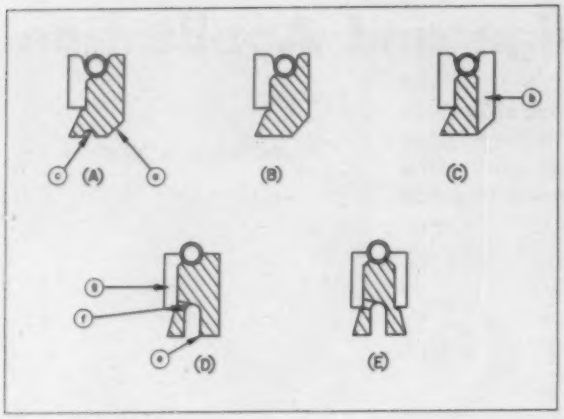


Fig. 4. Drawing shows five types of standard scraper rings

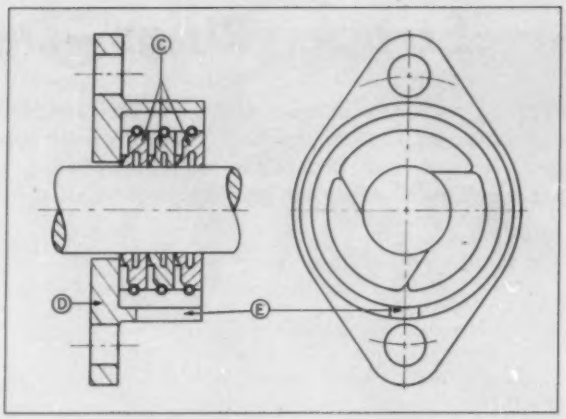


Fig. 5. Details of scraper ring set, also showing packing gland

are usually cast into the ring and must be large enough to carry away all fluid scraped from the rod.

3. Garter spring — main purpose of this spring is to hold the segments of the ring onto the surface of the rod, with a pressure sufficient to insure adequate scraping, and yet not so great as to cause excessive wear — either to the ring or to the rod.

4. Joint — allowing independent action of each segment of the ring. These joints are usually tangential as shown, and must be tight, so as to prevent any seepage of fluid.

Scraper rings are made into segments to allow for wear of the ring so that the bore of the ring is always in intimate contact with the rod. This is accomplished by the use of tangential joints between the segments. Note that the joints of the rings in Fig. 3 are plane surfaces, parallel to the axis of the rod, and tangential to either rod or to a circle concentric to, and less than, the diameter of the rod.

Path followed by any point on the surface of a segment of a scraper ring, as it wears, is indeterminant. As the segments wear, the flat plane surfaces of the tangential joints remain in intimate contact with one another, and the bore of the rings remains in intimate contact with the rod. Thus a tight seal against the flow of fluid through the ring is presented even after considerable wear. An illustration of how a ring wears is shown in Fig. 3.

Scraper Ring Design

There are many forms of scraper rings on the market today. The cross sections of several typical examples are shown in Fig. 4. The following comparative comments can be made:

1. (A) is generally satisfactory for horizontal rods, and for vertical rods scraping upward. Although they are used on vertical rods scraping downward, an objection arises occasionally in that fluid can collect in the relieved area (a), and be carried upward on the next stroke. This same comment applies to (B). The main difference between (A) and (B) is the small groove (c) in (A), which serves to reduce the contact area between ring and rod, thereby tending to reduce wear.

2. (C) is generally the same configuration as (A) and (B), but differing in the ported area (b), which allows for drainage of any fluid collecting in the relieved area. This ring is satisfactory for vertical rods scraping downward, or on horizontal rods where large quantities of fluid are scraped, and additional drainage area is required.

3. (D) is a more special scraper ring which is similar to (A) and (B) but incorporates a machined drain groove, which acts as a second scraper edge (e), and a drilled hole (f), which leads scraped fluid back to the drain port (g).

4. (E) is a two-way scraper which may serve several purposes:

   a. Scrape two different fluids, and move them into a common reservoir.

   b. Scrape, on the back-stroke, any fluid which may have passed through the scraper set on the upstroke.

Figure 5 illustrates a typical scraper set in its gland. A scraper set usually consists of three rings per set as shown, or in many cases, of two rings per set. Normally when (A) or (B) in Fig. 4 are used, a minimum of three rings per set is recommended. When using (D) in Fig. 4, two rings per set will normally be satisfactory, due to the greater efficiency of these rings.

When scraper rings are made up into sets, usually no provision is made to prevent the alignment of the joints of two adjacent rings. This is due to the fact that the joints of the scrapers are sufficiently accurate to prevent the seepage of any fluid through the joints. Thus the alignment of the joints of the rings becomes a minor factor.

In Fig. 5, the gland (D) is usually bolted up metal-to-metal against a flat surface. A clearance is allowed between the rings and the groove formed by the gland and the flat surface. This clearance is made great enough to prevent binding of the rings in the groove, due to thermal expansion, and small enough to prevent excessive noise due to reciprocating movement of the rings with the motion of the rod.

Close Tolerance Stops Seepage

This clearance is also made small enough to insure adequate contact between the last ring and plate, thus preventing seepage of fluid between ring and plate. To further insure no seepage of fluid between the flank of the ring and the plate, both the rings and the plate should have flat, finely-finished surfaces.

Materials of the scraper rings depend upon fluid scraped, rod material, temperature, and relative motion between the ring and the rod. In most cases where the fluid scraped is a lubricant, a good grade of graphitic cast-iron can be used, since adequate lubrication will be obtained from the lubricant scraped. Where adequate lubricant is not available, a good bearing bronze should be used. Moderate corrosive conditions require that good bronze be used, whereas highly-corrosive conditions usually necessitate babbitt, or lead.

Scraper rings normally are made with a relatively smooth bore, and the exact rod diameter is duplicated in boring the rings. When particularly fast wear-in is desired, rings will be made of a material which tends to wear faster, or the rings can be given a rough bore. THE END

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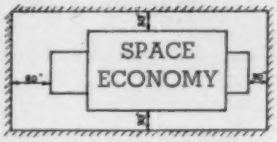
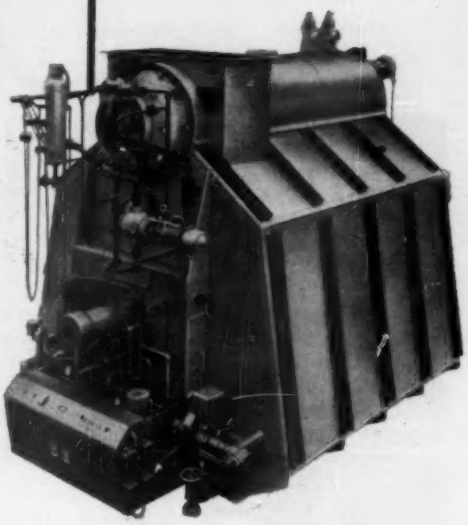


Where economy of space is a factor, consider the *actual* space needed. This boiler requires minimum tube removal space . . . a big boiler in a small package.



Designed to provide for industry the quality features so long associated only with big water tube boilers, the Superior Type AS Packaged Boiler brings to its capacity range (4,000 to 21,000 lbs./hr.) a new standard of boiler performance. Features are integrated for production of dry steam, sustained efficiencies, and maximum safety.

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Power Engineering handbook

Here's a Way to Arrange an Automatic Chemical Feeding Device

By FRANK E. ZIEGELMANN*

WE HAVE USED the device described here and find that it works very successfully. In this particular application it was used for adding chemical treatment to a brine system. Adding of the concentrated chemical to the chemical feed tank was formerly done manually, but on week-ends and holidays the tank wasn't large enough so that the chemical pump could run during that period of time, without draining the tank. Thus, we came up with this automatic feeder.

As the sketch shows, the chemical tank has a float switch mounted on the side of the tank. When the level drops down to a predetermined level, the float switch energizes the solenoid valve on the water supply line. This water supply line has a branch line leading to the chemical measuring cup, and is equipped with a throttling valve. Water then flows into cup and into tank. The cup is equipped with a siphon and an overflow.

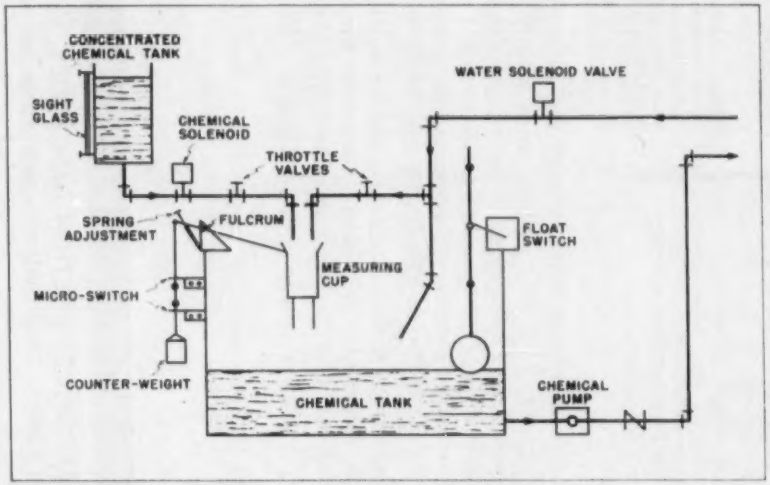

Fig. 1. Chemical tank has a float switch mounted on its side. When the level drops down to a predetermined level, the switch energizes the solenoid valve on water supply line, and process begins

fold along this line—outside edges toward you

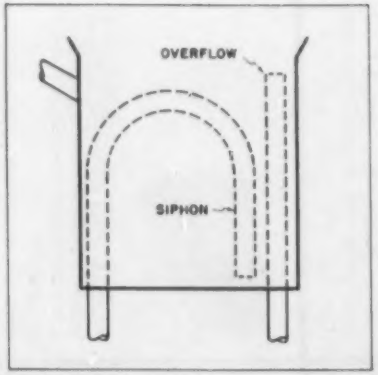

Fig. 2. Detail of construction of measuring cup

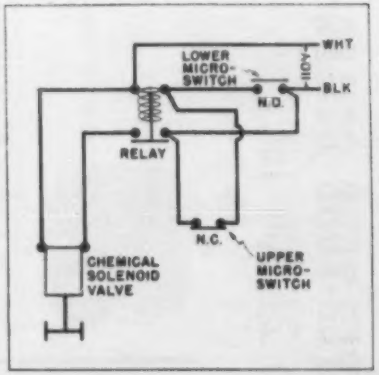

Fig. 3. This is wiring diagram for the device

Since a measured amount of chemical is in the cup, it is flushed out as soon as the water fills the cup and overflows through the siphon and the overflow lines. The water flow to the cup is throttled to maintain the siphoning action, until the water in the chemical tank actuates the float switch to de-energize the water solenoid valve. With the water ceasing to flow to the measuring cup, the siphon will drain the cup and cause it to be lighter. The counter-balance weight will then lift the cup up against an upper stop, which is a micro-switch.

The switch operates a relay which energizes the chemical tank solenoid valve, allowing the chemical to flow into the measuring cup. When enough chemical flows into the cup to overcome the counter-balance weight, the cup will drop down to its lower stop, which is another micro-switch. This switch de-energizes the relay which, in turn, de-energizes the chemical tank solenoid valve, shuting off the flow of chemical.

A spring is used to vary the amount of chemical fed to the cup. Tension on this spring is adjustable. The measuring cup now has the measured amount to be flushed into the tank on the next cycle.

Reason for the overflow line on the measuring cup is that the required amount of water necessary to maintain the siphon is easier to control. An excess amount of water is allowed to flow, with the excess water running out the overflow. Without the overflow, it was difficult to maintain the siphon.

This arrangement not only solved our problem but also eliminated the human factor of forgetting to add the chemicals.

*Powerhouse Engineer, Delco-Remy, Anaheim, Cal

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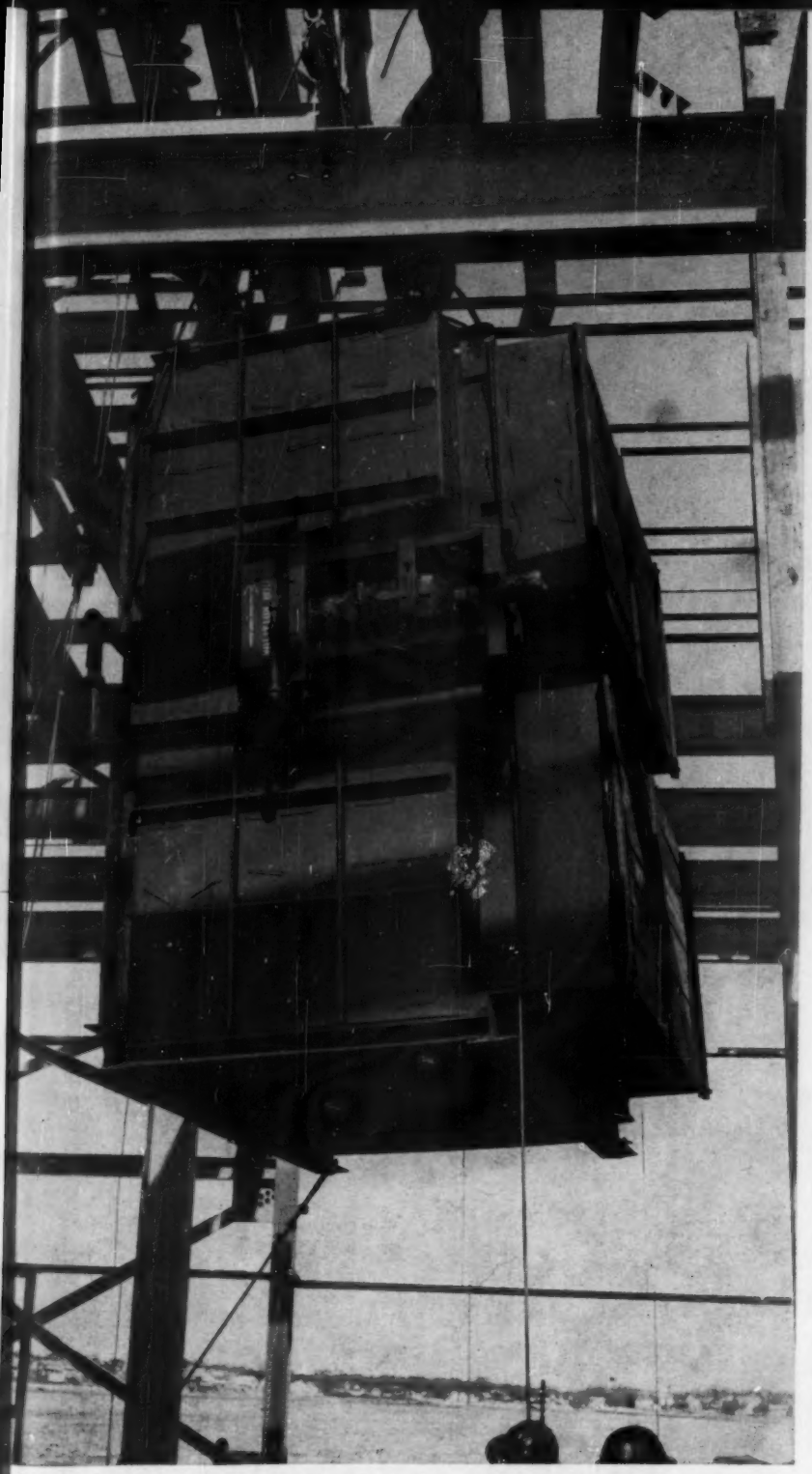

Complete and ready to run, Package Air Preheater is lowered through steelwork of new power station at Braintree, Mass. Installation at Braintree Electric Light Dept. uses largest available package preheater, with a diameter of approximately 12'. Fitted to a 130,000 lb per hr boiler, this Package Air Preheater will boost combustion air temperature by about 420°F with heat recovered from stack gas.

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Package design gives you these advantages on boilers as small as 25,000 pounds of steam per hour —or as large as 250,000 lbs per hr. And a Package Air Preheater is one of the surest ways to reduce fuel consumption: you cut your fuel bill 1% with every 45-50°F increase in preheated air temperature.

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Preventing CO_2 Corrosion in Condensate Lines

This discussion is a continuation of the author's analysis of CO_2 corrosion as he found it in working with boilers operating at pressures below 300 psi, and as he presented it in the Handbook for November, 1959

By RAMON M. GUZMAN*

MEASURES CAN BE TAKEN to prevent CO_2 corrosion in the return lines while the system is in the design stage. Properly designed systems and equipment can help reduce to a minimum the evolution of gases with the steam. Methods that can be incorporated to eliminate or reduce problems of this kind are as follows:

1. Treatment of make-up or feedwater to eliminate or reduce the amount of undesirable ions in the water.
2. Chemical treatment of the condensate.
3. Use of metals or alloys that are resistant to the corrosive action of the gases.
4. Venting of systems to reduce the concentration of CO_2 in the return lines.

The problem referred to can be virtually eliminated by using specific alloys in the manufacture of special piping. Because of economic reasons, however, the use of such materials can very seldom be justified for the sole purpose of preventing interior corrosion.

Cement-lined pipe has been used in various systems, as the cost slightly exceeds that of conventional pipe. The results obtained thus far, however, have not been encouraging. The failure of this type of pipe is probably related to the fact that the condensate is under its point of chemical stability in respect to calcium carbonate; thus the condensate tends to dissolve and deteriorate the cement that protects the pipe.

The Navy Department is conducting Utilities Conservation Surveys for the purpose of improving the operation of its utilities systems and detecting areas where savings can be accomplished. The surveys cover the areas of steam generation and distribution.[2] Action to reduce the CO_2 generated in a boiler may result from one of these surveys, as it is desirable to maintain steam generation and maintenance costs at a minimum. For example, the following items serve the purpose of reducing not only steam generation costs but also the incidence of CO_2 in the steam:

1. Maintaining an adequate control of the make-up water.
2. Preventing excessive losses of condensate and steam by repairing pipe leaks and steam traps.
3. Maintaining an adequate control of blowdown. As a general rule, the blowdown rate should not be much over five per cent in terms of boiler feedwater.
4. Preventing excessive radiation losses by maintaining the insulating material in good condition.

In fact, every measure that helps to reduce the steam exported will be a step to reduce the generation of CO_2 and the costs of operation.

Preventive Treatment

Various chemical treatments have been used satisfactorily to prevent CO_2 corrosion of condensate lines. Sulfuric and muriatic acid have been used to reduce the alkalinity of the make-up or feedwater. When using acids, it is necessary to maintain a close control, as an excess of acid may result in the injection of a corrosive water to the boiler. As a general rule, the alkalinity may be reduced to about 20 mg/l, or to an amount that will limit the generation of CO_2 to a satisfactory level. The chart reproduced with the earlier article (POWER ENGINEERING, November, 1959, page 102) can be used to estimate the reduction of alkalinity that is necessary.

Ion exchange resins are used for the external treatment of make-up water, thus removing troublesome calcium and magnesium ions. Softening of water by hydrogen zeolite eliminates the alkalinity of the make-up water, thus preventing the generation of CO_2 in the boiler. Sodium zeolite softening, however, does not eliminate alkalinity; it is transformed to sodium alkalinity and consequently does not have any influence in the reduction or elimination of the CO_2 that may be generated in the boiler.

Other chemical compounds that have been utilized for this purpose are the polyphosphates. These compounds have been successful in preventing interior corrosion of pipelines in domestic water systems; however, they have not proved too efficient in preventing corrosion in steam condensate lines.

Probably the chemical method most utilized in recent years to prevent corrosion of steam condensate lines is amine treatment. There are two types of amines used for this purpose, namely, neutralizing and filming amines. The neutralizing amines, as the name implies, raise the pH of the condensate, thus eliminating or reducing the corrosive action of the carbonic acid. Neutralizing amines used for this are cyclohexylamine and morpholine.

Main disadvantage of using a neutralizing amine is that it affords protection only from the corrosive effects of CO_2, but does not offer protection against corrosion from other gases. Besides, neutralizing amines usually require a relatively high amount of chemical to work satisfactorily; thus the cost of treatment is high.

Filming amines, such as octadecylamine (commercial names, Hagafilm, Permacol, Filmeen, Coravol), work on a different principle. This type of amines has the ability to deposit a protective film on the interior surface of the pipes.

This table shows some of the various methods used to control CO_2 corrosion. Each method should be carefully evaluated in terms of the characteristics of the individual system under consideration

METHOD	MECHANISM	ADVANTAGES	DISADVANTAGES
1. Filming amines	Forms a protective layer on interior surface of pipeline.	Simple operation. Protects from corrosive action of all gases. Promotes dropwise condensation of steam. May increase heat transfer efficiency.	Losses occur at every vent in the system. Large quantities escape with vented vapors from the deaerator. Too volatile.
2. Neutralizing amines	Neutralizes carbonic acid in the condensate.	Simple operation. Simple control tests.	Requires high dosages. No protection against dissolved oxygen. High cost of treatment.
3. Acid treatment	Reduces carbonate and bicarbonate alkalinity of the make-up or feedwater	Low cost of operation. Simple control tests.	Needs careful control. Overdosage may result in the injection of corrosive water to the boiler.
4. Venting of units	Less partial pressure of gases in the condensate lines. Less dissolution of gases in the condensate.	Simplicity of operation. Protects against all gases. Low cost.	Improper operation may result in the entrance of corrosive gases.
5. Hydrogen zeolite softening	Eliminates the alkalinity of the water with a resultant highly acid water	Complete reduction of alkalinity; thus no generation of carbon dioxide.	Limited application. High cost. Complex operation. Dissolved oxygen is increased.
6. Polyphosphates	Forms a protective layer on the interior of the pipeline.	Low dosages. Simple operation.	Limited application. Optimum dose is difficult to control. Results not reliable.
7. Alkaline chemicals	Neutralizes carbonic acid in the condensate.	Low cost. Simple control test.	Requires careful control. No protection against dissolved oxygen.
8. Reduction of make-up	Lowers CO_2 that may be generated by boiler.	Reduces operational costs.	Not always feasible.

*Special Assistant for Sanitary Engineering, Area Public Works Office, Caribbean, U. S. Navy, San Juan, P.R.

POWER ENGINEERING HANDBOOK

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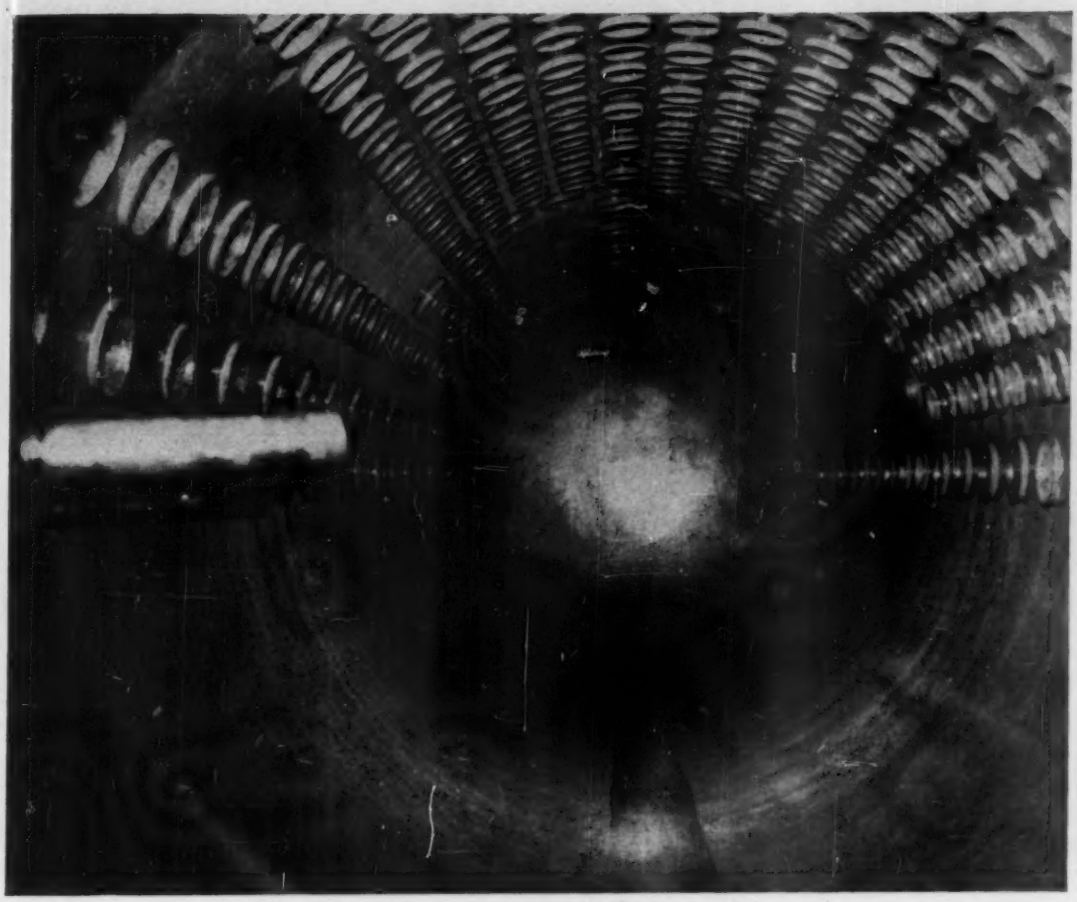

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Required dosage rate to be injected is not dependent on the amount of carbonic acid in the condensate, as is the case with neutralizing amines. Main advantage of the filming amines is that they afford protection against all corrosive action in the condensate lines. However, there are limitations.

A few years ago, the Bureau of Medicine and Surgery of the Navy Department indicated that octadecylamine is toxic and consequently was not recommended for certain domestic purposes. For this reason, the U. S. Navy has been utilizing neutralizing amines in preference to filming amines in those situations where the chemical might be ingested.[3] On the other hand, reports on recent developments tend to indicate that refined octadecylamine has shown no toxic effects to laboratory animals, even at one hundred times the normal concentrations regularly used in steam systems.

There are other chemical treatment methods that are used to control this type of corrosion. The table contains some of these methods, together with some of their advantages and disadvantages.

Demand of industry for higher steam pressures has increased the problems in the prevention of corrosion in condensate lines. Recent research indicates that when using sodium sulfite as an oxygen scavenger in boilers operating above 800 psi, the sulfite-ion is auto-oxidized.[4] This results in the liberation of sulfurous gases that reach the condensate lines, where they combine with the condensate to produce corrosive acids. To prevent this difficulty, catalyzed sodium sulfite has been used successfully.

It should be kept in mind that the extensive field of corrosion is in its experimental stage, and not all the theories proposed have been explained satisfactorily. It is a known fact that while using methods considered satisfactory, there will be some corrosion that cannot be controlled to the fullest extent.[5] The above methods can prevent or greatly reduce return line corrosion if properly controlled and properly applied.

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1. Collins, L. F. Corrosion of Steam Condensate Lines, The Corrosion Handbook, J. Wiley & Sons, Inc., New York, 1956.
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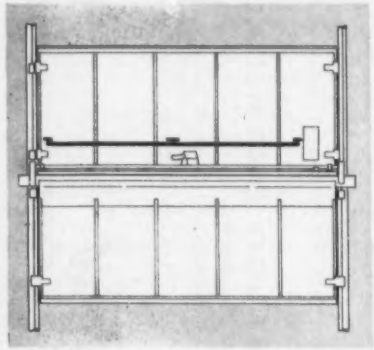
3. Gleason, R. J. Morpholine Treatment for the Control of Condensate Return Line Corrosion, a paper presented at the Second BUDOCKS Conference of District Sanitary Engineers, Cincinnati, Ohio, March, 1958.
4. Rummell, J. K. & Alexander, R. C. The Quality of Steam Condensate as Related to Sodium Sulfite in the Boiler Water, Trns. ASME, 72:510.
5. Noll, D. E. Limitation of Chemical Means of Controlling Corrosion in Boilers, *Corrosion*, 14:541 (November, 1958).

Watch Out for Those Elevator Doors!



½-in. round iron bar across upper half of elevator door takes place of center pull-down strap, keeping operators' hands out of the danger zone

By PAUL C. ZIEMKE

ELEVATOR GATES and doors are the bane of the maintenance engineer, especially in production plants operating around the clock.

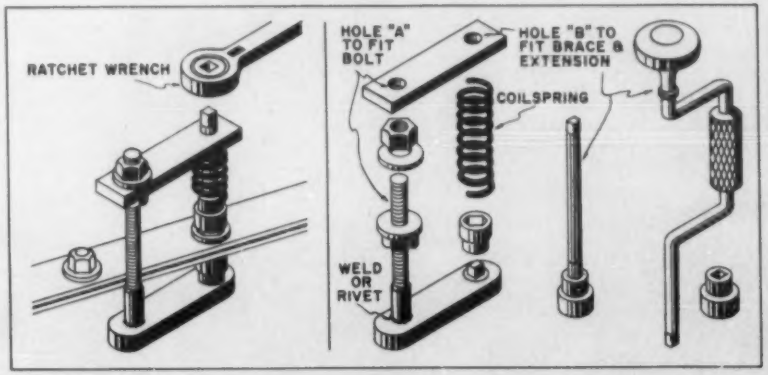
The steel door with upper and lower halves has a high starting inertia which results in the operator lunging at the pull-down strap. Thus the halves come together with a grand slam. In reverse order, quite a heave is required to start the halves opening. The cautious boys let go of the strap before the catch closes, lest their fingers get caught. Then the free swinging strap gets jammed. This is where the hand injuries occur, as well as some back strains!

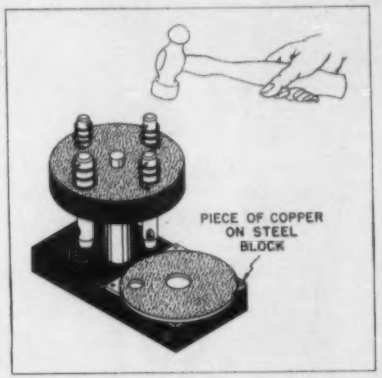
With a suggestion box system in the plant, the committee "bought" several ideas to eliminate this hazard. Among them was the idea of fluffing out the edges with sponge rubber, to soften the blow. Still another suggested a longer strap, and a third asked to have the strap's point of attachment raised on the side of the door. That way, the shorties were stymied until a longer strap was installed, and the old hazard, of course, was back with us, yet unsolved.

The answer lay in the installation of a ⅝-in. round iron bar, bent at right angles at the ends, flattened and drilled for bolting, with a third bracket welded in the center to avoid springing. This bar permits operation of the doors by more than one person, allows manipulation from any point in the front of the car, and certainly keeps the hands out of the danger zone.

There's a moral here, too: when writing specifications for a new elevator, include motorized doors. It's a smart move which speeds service and keeps accidents low.

fold along this line—outside edges toward you





Useful Shop Tricks

By CHARLES H. WILLEY

SHOWN ABOVE is a nut holder, or helper, made to hold that nut on the other side. It's made to use with snap-on type of socket wrenches, for adaptability.

At left is a punch holder which acts as a third hand, speeding up the work. Made to hold four or six favorite-size hole punches with stripper springs, the turret plate is mounted on a double-shouldered stud. Bottom end is a drive fitted into a steel base plate. Piece of copper or brass is used on the steel base to protect punch-cutting edges.

You can control hot water temperatures automatically–economically

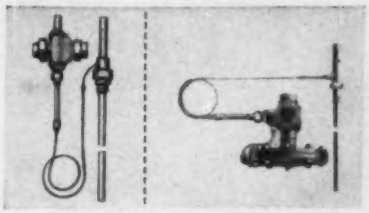
By John W. Ritter, Test Engineer
SARCO Company, Inc.

A dependable supply of hot water at exactly the right temperature for employee comfort is just as important a task for the plant engineer as providing properly heated water for process requirements. Fortunately, accurate, reliable regulation of water temperature is easy to achieve *economically* through the use of properly selected temperature controls.

It's impossible to maintain constant supervision of the delivered temperature of hot water with manual controls. Accommodating fluctuating loads that vary all the way from zero to peak requires automatic temperature regulation, controls that stay on the job all day long.

What to look for:

Automatic regulators are not difficult to select if you bear in mind the degree of control you require. You need reliability within a fairly constant predetermined temperature range – anything more than the *simplest mechanism to do this job is a waste of money.*

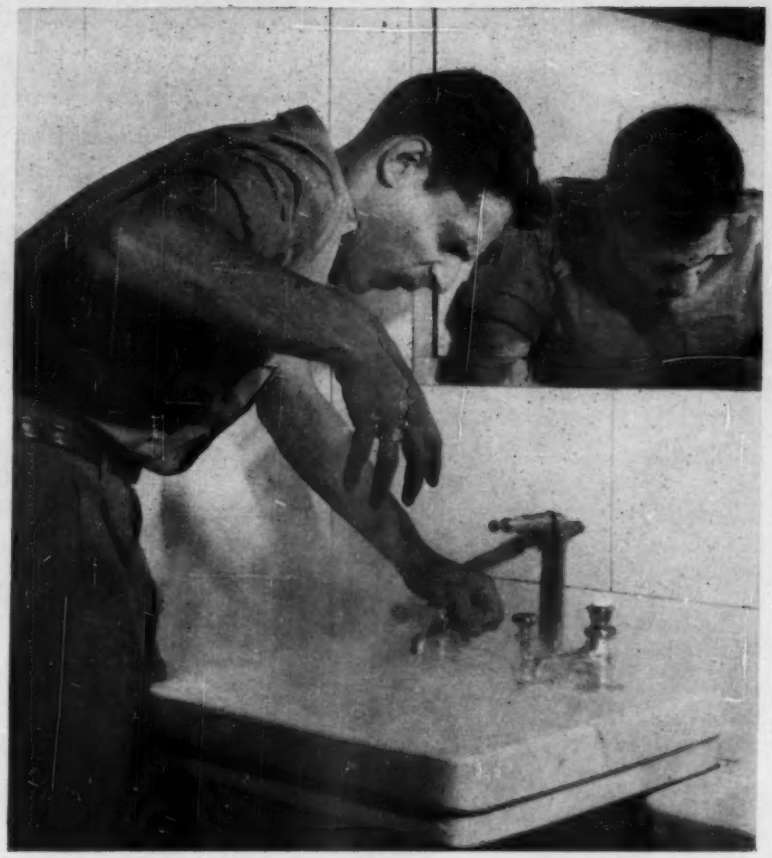


Sarco Type 50-21 Self-Powered Temperature Regulator

Sarco Type 24-30 Self-Powered Pilot Operated Temperature Regulator

First cost is important, naturally; but it is also well to examine very carefully the cost of installing or maintaining a temperature regulator. A pipe fitter should be able to do the job. When all these criteria are applied to regulator selection, the logical choice narrows to a self-operated type like the Sarco 24-30 pilot-operated model or the fully-modulating 50-21. Both of these regulators operate by powerful self-contained hydraulic systems that provide smooth operation with even increments over their full temperature range.

Both Sarco self-operated types give you automatic temperature control without high cost. The result: hot water constantly supplied at the required temperature regardless of fluctuations in supply or demand.



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Important . . . Correction: This article by John D. Constance on finding air and gas flow through perforated panels and pipe appeared originally in the October issue. Unfortunately, in transcribing the graphs certain errors crept in. So here's the article again, shipshape and correct. Sorry for the confusion in the original.

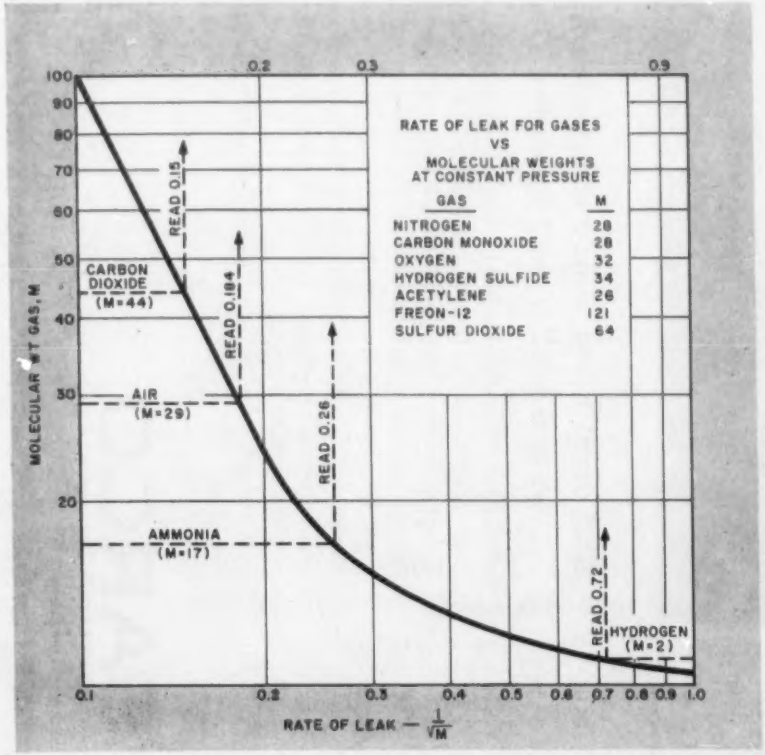

Fig. 1. Use this graph along with that of Fig. 2 to solve flow problems for gases other than air

THE LITERATURE carries considerable information on air and gas flow through orifices in pipes, but none is readily available on flow through perforated plates, panels, or pipe. To fill in this gap, the graph in Fig. 2 is presented.

Perforated thin plates are used as ceiling panels for distribution of conditioned air, distribution plates at the base of spray towers, or any other application where even distribution of air or other gases is required.

Although this graph applies to air, it may be used in connection with Fig. 1 to solve similar flow problems with other gases. Figure 1 gives correction multipliers to be used with the basic air flow determined from Fig. 2. Thus, for carbon dioxide the flow factor would be 0.15 (carbon dioxide)/0.184 (air) = 0.81. First find flow for air using Fig. 2, then multiply this value by the factor above.

Example: Ammonia gas at a static pressure of 0.10 water gage (w. g.), 20 per cent open area, find flow rate per sq ft gross area.

Answer. From Fig. 2 for air 175 cfm per sq ft gross area. Flow factor is 0.26/0.184 = 1.41. Ammonia flow rate then is

175 × 1.41 = 247 cfm per sq ft gross panel area.

Note that plate curvature does not materially affect flow. Plate material may be steel sheet for air or stainless steel sheet for corrosive gases.

fold along this line—outside edges toward you

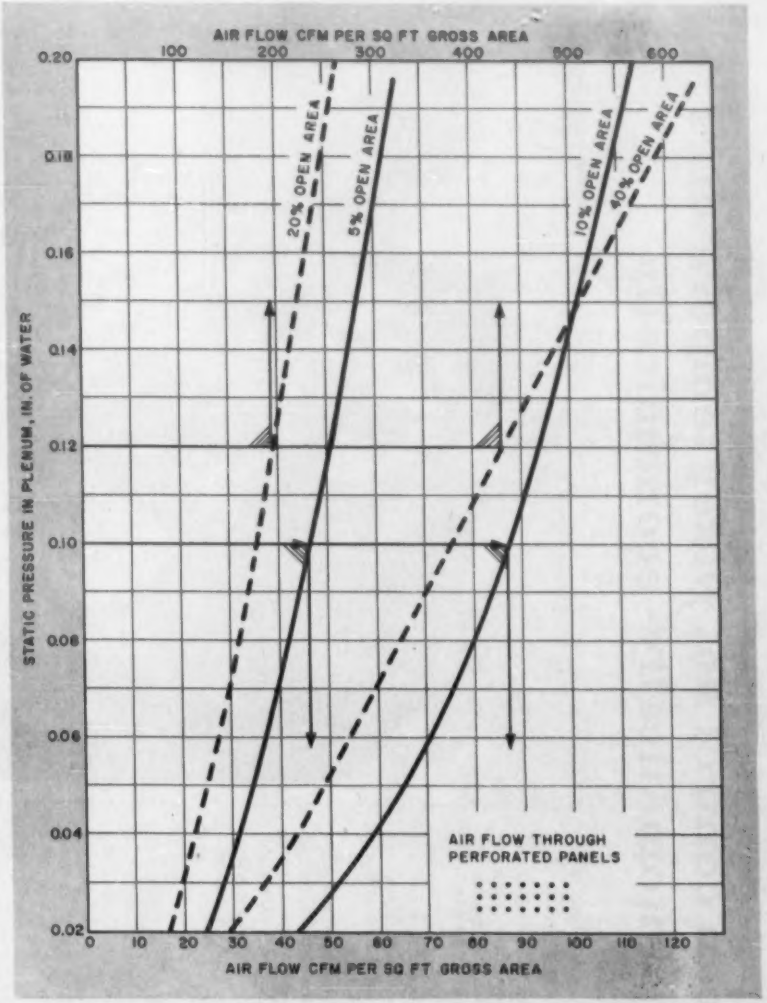
AIR FLOW CFM PER SQ FT GROSS AREA
20% OPEN AREA
5% OPEN AREA
10% OPEN AREA
40% OPEN AREA
STATIC PRESSURE IN PLENUM, IN. OF WATER
AIR FLOW THROUGH
PERFORATED PANELS
AIR FLOW CFM PER SQ FT GROSS AREA

Fig. 2. This graph applies to air flow, but with the correction multipliers supplied by Fig. 1 can be used for other gases. Conditions are for atmospheric air at 70 F and close to atmospheric pressure

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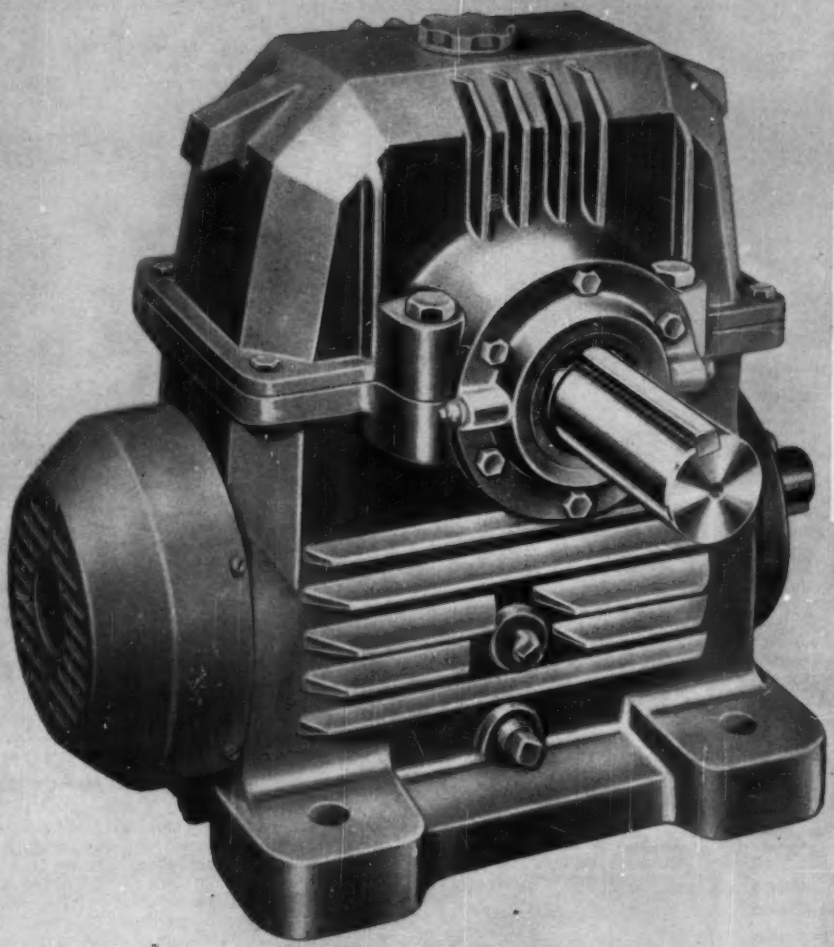

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fan cooled
5" through 12"
center
distance
★

Send for this new 32-page Bulletin 3805 today.

New Delroyd single reduction speed reducers are available in a wide range of sizes and horsepower ratings. These worm gear units include centrifugally cast gears and fan cooling, and carry *the new AGMA ratings.*

DE LAVAL *Steam Turbine Company*

816 NOTTINGHAM WAY, TRENTON 2, N. J.

DL 478

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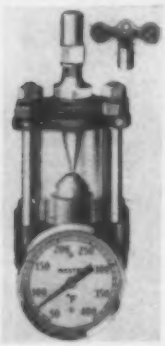
EQUIPMENT NEWS

Described on these pages are new and improved products. Use Reader Service Cards on pages 115–116 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

1—FLOW REGULATOR works without moving parts

The Series 300 Micro Adjustable Orifice is essentially an adjustable needle valve encased in a sight glass. It is designed to be used instead of steam traps for drainage of heating and processing units operating continually at pressures up to 60 psi. The orifice works without moving parts, company says, providing continuous circulation of condensate with virtually no maintenance. Flow of condensate may be minutely regulated by hand key. Sight glass and optional thermometer permit constant visual check. Orifice is made for pipe sizes from ½ to 1 in. Stickle Steam Specialties Co.

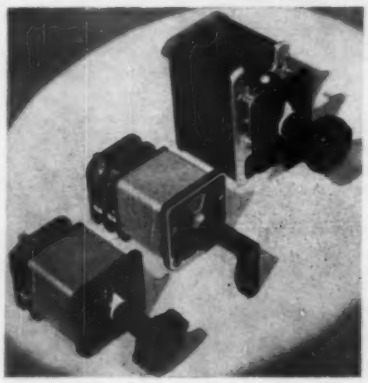


2—OXYGEN ANALYZER for suppressed range application

Operating in conjunction with company's electronic receiver and a suitable sampling system, the Model 633 combines with these components to form a system for analyzing and recording, and/or indicating the oxygen content of a gas on suppressed range applications. For applications where oxygen content of gas to be analyzed is 30 per cent or less, the minimum instrument span is 1 per cent — for example, from 21 to 22 per cent. Maximum instrument span in this situation is 6 per cent — from 7 to 13 per cent, for example. Where oxygen content is greater than 30 per cent, minimum span is 2 per cent, maximum 6 per cent. Accuracy of the Model 633 is claimed ± 2 per cent of scale. Instrument features divided flow assembly designed to reduce possibility of cell damage due to dirty, wet sample gas. The Hays Corp.

3—CONTROL SWITCH uses little panel space

The SBM is announced as a compact switch for switchboard applications where space is at a premium. It has two mechanically and electrically independent contacts per stage, each with an individual double-surface cam designed to give positive opening and closing not dependent on springs. Switch is described as 40 per cent smaller over-all, using 55 per cent less panel space than previous switches of similar ratings. A self-enclosing envelope, open only at bottom, houses each stage of cams and contacts. Rated for mechanical life of 500,000 operations, SBM's electrical ratings are 300 v a-c or d-c, 20 amp continuous. General Electric Co.



4—PORTABLE SPACE HEATER burns liquid petroleum gas

Model LPG200 is intended for providing temporary comfort heating in maintenance shops, warehouses, dock areas and other locations not having central heating, as well as for thawing out frozen equipment and materials. The heater is radiant and recirculating, engineered for quiet sootless production of high volume heat — up to 200,000 Btu. A ⅓-hp motor drives a fan that circulates warm air at a rate of 2000 cfm. The standard model includes a burner control designed to turn off fuel should the power fail or flow of gas be interrupted. The heater weighs only 45 lb, is readily connected to a gas bottle and a 110-v a-c outlet. Stow Mfg. Co.

5—NON-ACID DE-SCALER removes scale from boilers

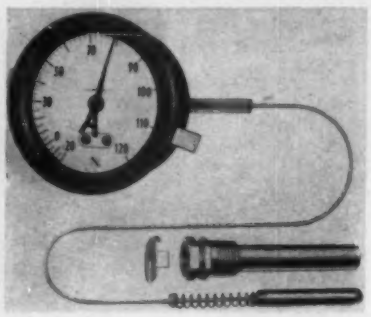
Aidco 10 is announced as an organic chemical which deactivates scale from boilers, heat exchangers, condensers, pipelines and refrigeration coils. Described as practically odorless, non-toxic, non-flammable and non-corrosive, manufacturer says it can be used safely and conveniently without special protective clothing. For normal de-scaling, 1 gal of Aidco 10 is added to 6 gal of water and circulated at a temperature from 160 to 180 F at a minimum pressure of 25 psi. Used as a scale inhibitor after de-scaling, it can be metered into a system at a concentration of 15 to 30 ppm. Alloy Industries Development Co.

6—REPLACEMENT UNIT for thermostatic steam traps

Tough Monel cage is designed to protect the bellows from erosive condensate flow in this one-piece cage replacement unit for thermostatic steam traps — up to 250 psig. Unit is factory-calibrated and pre-set in unalterable alignment. Inside the Monel cage is the Monel bellows with liquid fill. Seat plug is universal-jointed stainless steel ball, designed to seat tightly due to in-line placement over steel valve, eliminating bellows side-strain. Replacement consists of removal of trap cover, removal of worn unit pieces, insertion of replacement, and re-covering of repaired trap. Barnes & Jones, Inc.

7—DIAL THERMOMETER is remote reading instrument

Type 6440 and 6470 Series of vapor pressure actuated dial thermometer, 2½ in. in size, provides convenient reading of duct temperatures on air conditioning equipment, frozen food cabinets, pumps and oil circulating systems. Features of this adaptable instrument include: spring-clamp bulb and well assembly to



allow for conversion from plain to well-type bulb in seconds, small diameter copper capillary tubing which can be positioned out of sight, adjustable pointer, gaskets to keep the thermometer "splash proof" on wet installations, and flush mounting by front flange or U-clamp. Ranges are from −40/65 F to 260/450 F and 0/100 C to 90/185 C. Manning, Maxwell & Moore, Inc.

8—LUBE OIL CONDITIONER for diesel engines

Barsad Lube Oil Conditioner is announced as a chemical treatment designed to neutralize the acidity of crankcase circulating system oils in large diesel engines. It is noted that particularly in diesels burning heavy fuels, sulfur by-products of combustion enter the crankcase circulating oil, causing an increase in neutralization number and strong acid number. Barsad Lube Oil Conditioner is claimed to restore the oil to a safe pH value, so that it will not corrode crankshaft bearings. R. S. Norris & Associates.

9—CABLE-TYPE FUSE LINK fits any distribution cutout

This cable-type universal fuse link uses a removable button head and is announced for use with all open and enclosed distribution fuse cutouts. According to company, more positive low

Crane diaphragm valves on gas lines to boilers...8 years with no maintenance

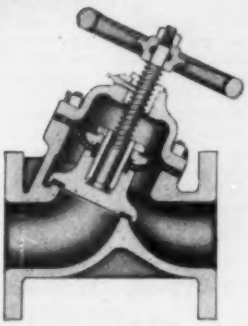
Before Union Electric Co.'s Venice Station, St. Louis, changed to Crane packless diaphragm valves, the plug valves used on natural gas fuel lines to boilers were causing costly maintenance. Records showed excessive repacking and accelerated seat wear.

Since changing to Crane valves in 1951, there has been no leakage, no seat wear, no trouble of any kind. Tight seating is assured by the resilient, neoprene disc-insert that actually absorbs hard foreign particles. The disc and diaphragm are separate members. The diaphragm functions only to seal the bonnet and is not subject to the crushing or severe flexing that can cause early rupture in ordinary diaphragm valves. The disc insures tight closure even if the diaphragm should fail. After eight years' continuous, maintenance-free service, the Crane valves still seat tight—show no sign of wear.

The same Crane features that perform so well on gas service save Union Electric many maintenance dollars on raw river water lines used for ash sluicing and on compressed air and other water lines. They can do the same for you.

Write for free booklet

Get the complete story on Crane diaphragm valves. Ask your Crane Representative for Bulletin AD-1942, or write to the address below.



Note separate disc-diaphragm construction. Diaphragm serves only as bonnet seal while disc does the seating—holds line fluid even if diaphragm should fail. Wide choice of body, trim and lining materials. Screwed or flanged ends.

CRANE® VALVES & FITTINGS

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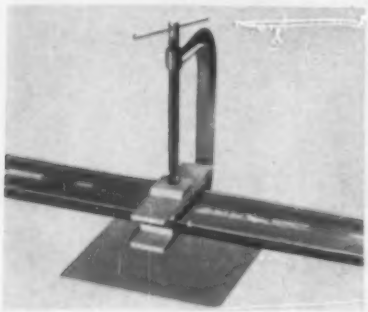
current clearing is possible with the link because of a longer auxiliary tube than on previous units and an internal spring — on fuses up to 20 amp. Also, tube is sealed at top of cable-type link to prevent gas escaping. General Electric Co.

10—ANNUNCIATOR operates without moving parts

Statalarm is designed to perform all functions for which relay annunciators are now employed. According to manufacturer, it features long life (100 million operations or more) for flashers and lamp bulbs and is completely transistorized. All sequences are available in flashing or color. Available for use with any voltage (240 v a-c, 120 v a-c, 48 v a-c or d-c, 24 v a-c or d-c, 12 v a-c or d-c are standard), Statalarm can be used with normally open or closed alarm contacts. All transistors are interchangeable, and built-in emergency power supply is available. Lundell & Co.

11—RUBBER WATERSTOP splices in just 6 min

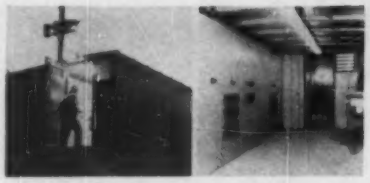
With Kwik-Seal Rubber Waterstop, strong, permanent splices can be made in 6 min, it is announced — five times faster than with former methods. Instead of requiring heat-sealing or vul-



canization, the Kwik-Seal splice is chemically bonded. Only a small splicing kit and simple clamping device are required. Both waterstop and splice meet or exceed government requirements, it is claimed, and the waterstop retains a watertight seal even when movement occurs in a concrete joint. It is suggested for preventing seepage and leakage wherever concrete is used, as in power stations, pumping and water stations, tanks, wall base joints, building foundation walls. Gates Rubber Co.

12—12-IN. RECORDER for temperature or pressure

Up to four recording pens can be provided on this 12-in. recorder, for temperature, pressure, or a combination of the two variables. Filled-system thermometer elements are designed to measure temperatures from —300 to 1200 F (fills include mercury, vapor, gas, and organic liquid). According to company, pressures from 30 in. of mercury vacuum to 25,000 psi can be recorded (elements include spiral, bellows, C-type Bourdon tube). Recorder features improved case with recessed bottom that permits one type of connection for both wall or panel mounting, and an extra large opening in door for better visibility. U. S. Gauge, Div. American Machine & Metals, Inc.



13—WORK AISLE for the metal-clad switchgear

This work aisle for 5- and 15-kv metal-clad switchgear is designed to provide safe and comfortable conditions for inspection and maintenance in all kinds of weather, protecting both maintenance crews and switchgear. Wide aisle design allows space for breakers to be completely withdrawn, company says, with enough space for two breakers to pass in case they have to be interchanged. There is also room for a work desk and a testing panel. Of steel construction, the work aisle is mounted on piers and has strip heaters and fluorescent lighting. Federal Pacific Electric Co.

14—INVERTED BUCKET TRAP offers design changes

This series of inverted bucket traps is designed to expand company's Duo-Step Leverage line, providing horizontal connections ranging from ½ to 1¼ in. IPS. The traps feature high pressure cast iron construction, pressures to 250 psi and temperatures to 450 F. Duo-Step Leverage, a double-fulcrum leverage principle, is designed to provide large drainage capacities while holding physical trap size to minimum. Bulletin 230-A gives details. The Clark Mfg. Co.

15—OVERLOAD INDICATOR for water clarifier units

Protecta-Trol, an overload indicator and controller for water clarification units, registers sludge overload on an indicator and has contacts for alarm or light signals and for shutdown of unit. It is offered as regular equipment on company's Reactivator line of solids-contact clarifiers and softeners, and on Rota-Rake Clarifiers, horizontal flow gravity separators. Protecta-Trol is housed in a galvanized cast iron, weather-tight assembly. It works off the input worm of speed reducer which is spring loaded so that any increase in load above a preset point causes worm shaft to compress the spring and allows the shaft to move. Moving shaft actuates a sensing plunger which causes movement of pointer on scale. Graver Water Conditioning Co.

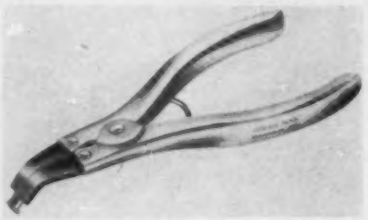
16—CONTROL SYSTEM for industrial process installations

PowrMag Systems are solid state, electronic controls containing no tubes, slide wires or transistors, yet said to have almost universal application to industrial process control. Adaptable to simple single controller installations or to large multi-plant systems with direct tie-in to data processing or digital computing equipment, the PowrMag analog computer concept reportedly embodies a high degree of flexibility. Because of the universal language and design techniques of analog computers, PowrMag control is claimed ideal for new systems or for expansion of existing control facilities where pneumatic loops must be tied into new equipment.

A typical PowrMag System consists of four basic elements: 1) input transducers which convert input variables such as pressure, flows, temperatures and level into 1–9 v d-c electrical signals; 2) analog control computers which add, subtract, multiply, integrate, differentiate and perform other functions; 3) remote control stations, located on the central control panel, which provide precess set point, bias, ratio and other manually set control operations with output and null indicators; 4) final control units, such as electro-pneumatic and electro-hydraulic valves and power positioners. Bulletin MSP-163 gives full data. Controls Div., Hagan Chemicals & Controls, Inc.

17—HANDY TOOL eases link V-belt coupling, uncoupling

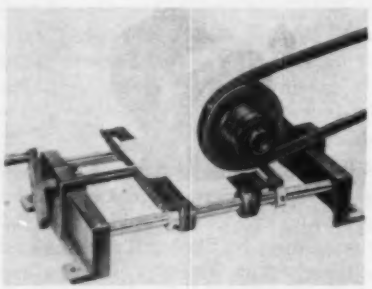
The Veelos Tool is designed for safe, easy coupling and uncoupling of link



V-belts. Made of heavy gage steel, the handles of the tool are cadmium plated. When these handles are squeezed, the points grip and open the hole in the link. Manheim Mfg. & Belting Co.

18—SPRING LOADED PULLEYS adjust pitch diameters on drives

This line of variable pitch pulleys features a spring tensioned sliding flange designed to automatically adjust to various pitch diameters and hold belt firmly. These pulleys are generally mounted on motor or driver shaft and are coupled by an A or B belt with fixed



diameter pulley to form the variable speed drive. Speed variation is accomplished by varying center distance between pulleys. As this distance shortens, the spring loaded variable pitch pulley automatically expands its pitch diameter to take up the belt slack, keeping the belt taut, and firmly seated in the pulley. As the center distance is lengthened, the pull of the belt on the spring loaded pulley brings a gradual contraction of its pitch diameter. Thus, the belt rides high on the spring loaded pulley in short center, high speed operations, and rides deep in the widened

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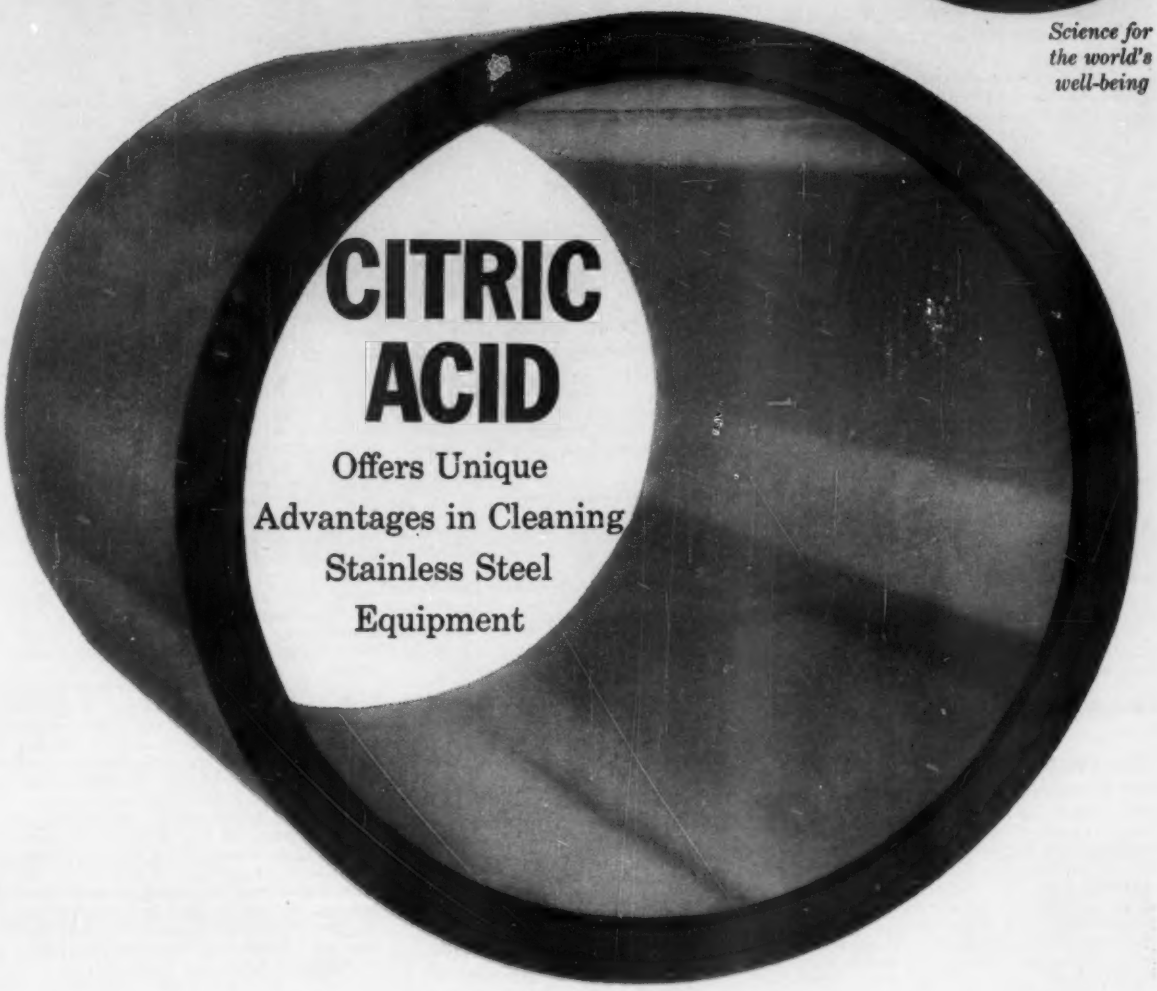

For chemical cleaning of stainless steel equipment such as boilers, heat exchangers, atomic reactors and chemical processing equipment, citric acid is the product of choice. Now, by using citric acid (which is chloride free), you can be sure *of safe, efficient cleaning with reduced after-rinsing.* Citric acid has a history of proven success.

Here are the unique advantages of Pfizer Citric Acid that you can discuss with your chemical cleaning service company:

1. Citric acid is highly efficient in removing imbedded metal and oxide film from stainless steel.

2. Citric acid's excellent sequestering ability prevents reprecipitation of dissolved scale.

3. Citric acid cleaning completely eliminates the possibility of chloride stress corrosion.

4. Citric acid can be effectively inhibited without losing its cleaning or sequestering ability.

5. Citric acid is sold as a dry, 100% acid—meaning savings in storage and handling.

6. Citric acid is water soluble, easy to handle, and non-toxic.

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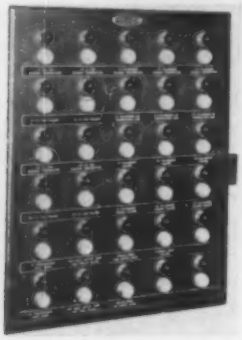
groove on lengthened center, low speed work. The spring loaded pulley mounts on any standard motor, is designed to work with A or B belts in drives within ½- to 2-hp range. Maurey Mfg. Corp.

19—ANNUNCIATOR pin-points component failure, too

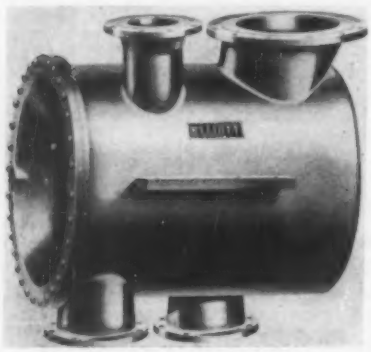
The Series 50FS Fail-Safe Annunciator is designed to enable operator to differentiate instantly between its own component failure and an "off-normal" field condition in the plant. It utilizes



two lamps per annunciator point — red alarm lamp indicates field abnormality, white lamp signals annunciator component failure and doubles as running lamp during such failure. Although annunciator component failure is infrequent, the 50FS is designed to eliminate guesswork checking and guard against faulty action which could destroy equipment or product. It also identifies failed position. Panellit, Inc.

20—CENTRIFUGAL COMPRESSOR for low-flow, high-head service

Developed for low-flow, high-pressure ratio applications, these centrifugal compressors feature simplicity, flexibility in materials of construction, and adaptability to handling gases other than air. They are available in both single- and two-stage designs. Advantages claimed are freedom from vibration or flow pulsations, light weight, and small space, ability to provide oil-free air, and need for only a simple, inex-



pensive foundation. Capacities range from 800 to 8,000 cfm, pressure to 1000 psia. The cast casing and forged impeller element can be made of materials to suit the application. Bearing housings and seal designs permit lubrication with water or other lubricants, manufacturer states, and obviate explosion hazards caused by oil contamination or toxic gas leakage. Bulletin P-12 gives further details on this. Elliott Co.

21—TRIP DEVICE needs no tripping battery

Major advantages claimed for this static, auto-charge trip device that trips breakers on either dead or faulted power lines are elimination of tripping battery, saving of space required by battery and reduced maintenance. Unit is designed to provide tripping power to open breakers even after a prolonged power outage. It eliminates need for low-energy, high-impact breaker tripping mechanisms, company notes, since it will trip breakers having conventional mechanisms. Device will be optional on company's two-cycle breakers. General Electric Co.

22—ELECTRONIC INDICATOR is versatile, clearly visible

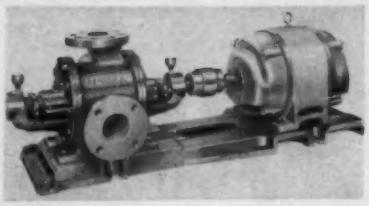
Model 721 Electronic Indicator is announced as a clearly visible electronic indicator whose use, with accessories, is to indicate values of flow, liquid, level, temperature, pressure, position, input

motion, a percent of oxygen, of hydrogen, of carbon dioxide, resistance, ph, and d-c millivolts. Either of two electronic receiver units can be incorporated for operation with suitable transmitters — a differential transformer receiver, or a slidewire receiver. Features of this indicator are a 4.4 sec pointer travel over full scale, with 300 deg indication and total scale length of 12¾ in. The unit is small, available in 14-gage sheet steel case with die-cast aluminum door. It is flanged for flush installation. Specification Sheet 59-B721 gives data. The Hays Corp.

23—TURBINE TYPE PUMPS feature design improvements

Among design changes in the Apco Two-Stage Turbine Type Pumps is a revised shell housing which directs fluid from the first to the second stage impeller in a 180-deg cross-over. By thus placing in opposition the resultant forces of first and second stages, the forces are equalized and a condition of balanced radial loads achieved, manufacturer explains; at the same time the arrangement eliminates shaft deflection. Removable channel provide for inexpensive replacement of eroded or corroded surfaces and wear is minimized by absence of metal-to-metal contact within pump channel — permitting handling of free-flowing or even non-lubricating fluids.

Within each series, capacities can be



increased or decreased by changing channel rings and impeller. The pump can be converted to right-hand or left-hand operation in the field without special parts. Capacities range up to 150 gpm, pressures to 300 psi. Aurora Pump Div., The New York Air Brake Co.

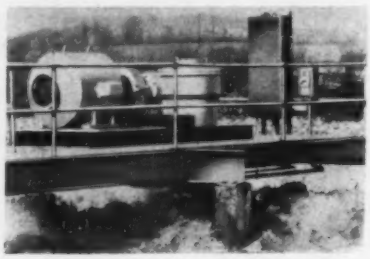
24—CONTROL VALVE has low pressure drop, friction loss

In the Straight-Flow Control Valve, flows move in a direct line through the valve at all throttling positions, it is announced, and this reduces pressure drop and friction loss while giving infinitely variable throttling. K factor of this valve is said to be only 0.35, about 1/30th that of many globe valves. Its principal advantage is ability to pass more fluid or gas for a given pressure and with less turbulence, letting a greater capacity be obtained from an installation without changing piping dimensions or increasing pressure. Resistance to clogging is another advantage cited; since all flow is concentrated in a triangle-shaped orifice, instead of an annular one, it allows passage of larger particles of solid material at any given orifice.

This method of flow regulation is accomplished by raising or lowering the stem which is placed at a selected angle to the flow. The stem has a 90-deg milled groove in the tip, the apex of which is parallel to flow direction. The stem does not rotate, but moves up or down in an angle. As the stem rises, a larger section of the V-groove is presented as flow area. Flow does not deviate from a straight line, it is pointed out. The valve has an outside stem and bonnet. It can be had in carbon steel, stainless steel and bronze. Pressure ratings are 600 to 10,000 psi; sizes, ⅛ to 4 in. General American Valve Co.

25—MECHANICAL AERATOR is low-cost, simple unit

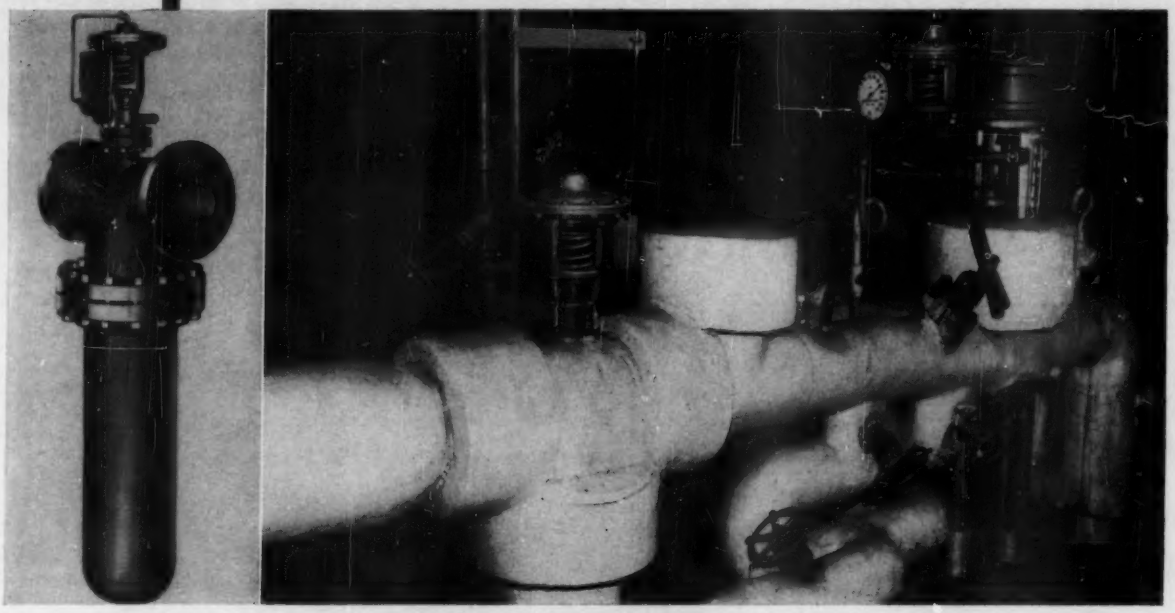
The Vortair is announced as a low-cost aerator for introducing atmospheric oxygen into an aeration basin or lagoon at any desired rate. Essentially a turbine type mechanical aerator, the Vortair ro-



tor is so shaped and mounted, and rotated at such speed, as to draw large quantities of air from atmosphere into the liquid. It also serves to keep liquid mixed and distribute oxygen through a

COPES VULCAN | BLAW-KNOX

How Copes-Vulcan control systems boost power plant efficiency



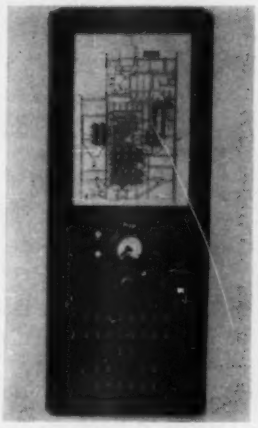
Carburetor-Type Desuperheater used at Barrett Station. Available in standard 2" through 12" sizes, in 150 through 600-pound pressure standards for cast steel. Larger sizes and higher pressure standards are available on special application. Final temperature may be held within plus-or-minus 5°F. Write for Bulletin 1056.

Copes-Vulcan reducing and desuperheating station takes load swings at Barrett Plant

Long Island Lighting Company uses a Copes-Vulcan desuperheating and pressure reducing station to handle seasonal demands for building heating at their Edward F. Barrett Station. Specifications require the station to condition flows of 500 to 25,000 pounds per hour, from 2015 psig and 1005°F. down to 165 psig and 385-400°F.

3,000 to 17,000 pounds per hour in 30 seconds. During evening hours in winter, the generating unit comes down to half load, or less, requiring the P-R-D station to feed pre-heater steam coils. When these coils are supplied from the P-R-D, the load swings from 3,000 to 17,000 pounds per hour in 30 seconds. The station, consisting of a Copes-Vulcan Carburetor-Type Desuperheater and a heavy-service piston-type valve, holds final (reduced) pressure and temperature constant.

Copes-Vulcan also offers two other types of desuperheater: a Steam-Assist (Bulletin 1024-A), and a Variable-Orifice type (Bulletin 1037).



Barrett Station controls soot blowing on Unit 1 with a Vulcan Automatic-Sequential System. For details, write for Bulletin 1029. (Panel shown gives automatic-sequential control for up to 60 soot blowers.)

Piston-type valves meet rigid requirements for unusually high operating force and accurate positioning. Copes-Vulcan also builds diaphragm-type CV-D Valves that have excellent rangeability. Write for Bulletin 1027.

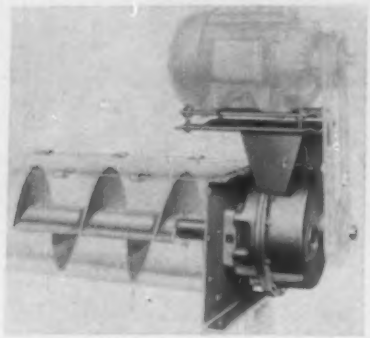
Copes-Vulcan Division
BLAW-KNOX COMPANY
Erie 4, Pennsylvania

For more data circle 557 on Post Card

mass of circulating liquid. According to company, power consumption is conservative, 2.5 to 3 lb of oxygen being dissolved per hour per horsepower. Bulletin 6620 gives data. Infilco Inc.

26—HELICAL GEAR DRIVE for screw conveyors

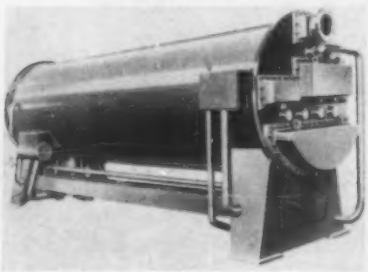
This compact helical gear drive, designed especially for screw conveyor installations, comes in six sizes, with ratios of 4:1, 9:1, 14:1 and 24:1, for all con-



veyors requiring ½ to 30 hp. Drive shafts are removable, by means of a snap ring arrangement, and on many applications can be removed without disturbing reducer or screw. Trough ends, available in eight sizes from 6 to 20 in., bolt to standard troughs. Choice of seals (waste packing, felt seal, or lip seal, either leather or Neoprene) is offered between conveyor and reducer. The basic drive can be combined with standard trough end as well as with company's motor mount. Bulletin 7106 provides information. The Falk Corp.

27—COLD GENERATOR is completely hermetic absorption unit

This hermetic absorption cold generator is powered by low-pressure steam and uses water as the refrigerent with lithium bromide as the absorbent. Single-shell design and hermetic pumps are designed to prevent air leakage to maintain full-



rated capacity and resist oxidation. Purging of air from the machine is required only a few times a year, company says, due to hermetic design and simplified purge system. It is noted that a control operates the machine at conditions to avoid crystallization, but should crystallization occur, due to periods of power failure, unit is designed to free itself once normal conditions are restored. Unit has capacities from 100 to 350 tons, is suited for single or multiple unit installations for comfort conditioning as well as for industrial processing and cooling. The Trane Co.

Reader Service Cards on pages 115–116 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

28—CIRCUIT BREAKER is compact, hydraulic-magnetic unit

Described as unusually small for its 200-amp rating, the SE33 Hydraulic-Magnetic Circuit Breaker utilizes company's Companion-Trip feature. Poles are in separate "compartments" within the common case to provide effective di-electric separation of breaker contacts. They are linked externally by a single handle. A kick-spring serves to provide emphatic tripping action when an overload occurs on either pole. The magnetically actuated breaker reacts only to load current changes produced in a solenoid sensing coil. Ambient tempera-

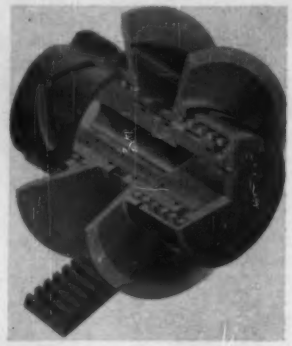
tures are said to have no effect upon breaker's current rating or trip points, and Instantaneous tripping at 10 times breaking rate, or above, provides fast interruption under short circuit conditions. According to company, the basic magnetic design principle makes derating and other temperature compensations unnecessary. Since it is nonthermal, unit can be reset immediately after a fault has been corrected. Rated at 120/240 v a-c, it has interrupting capacity of 10,000 amp., comes in ratings of 125, 150, 175 and 200 amp. Heinemann Electric Co.

29—BOILER WATER GAGE for pressures to 3000 psi

The water level shows black in the Refraport Gage, and the steam space above shows as a line of brilliantly lighted bullseyes, company says, with a clean line of demarcation which makes it easy to read level directly or in TV or mirror transmission. Designed to use principles of light refraction, this steel gage has a single chamber with front and back ports. An illuminator at the back throws a beam through the ports. Light passing through water is refracted so it does not come through front ports, thus leaving them unlighted. Light passing through steam above water level, however, streams through front ports in series of brightly lighted spots. The high pressure of 3000 psi is attributed to design and use of circular glass inserts which withstand internal loads and thermal shocks applied in boiler water service. Jerguson Gage & Valve Co.

30—VARIABLE SPEED SHEAVE with motion control feature

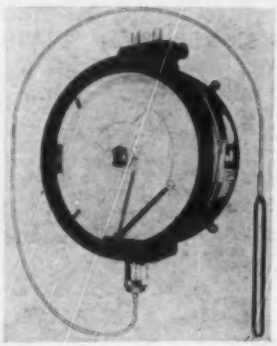
The MCS (Motion-Control Sheave) is designed to hold a constant driven speed during changing torque loads. A further advantage claimed is absence of freezing. No matter how long the sheave has been running at a set speed, company



says, it will not stick when speed has to be changed. It is noted that cam pressure is exerted only when load requires it, and power is transmitted equally to both movable flanges through a series of torsionally resilient rubber cam followers. Sidewall pressure on belt varies in proportion to torque required to carry load. Since grip on belt increases as load increases, pitch diameter is maintained and driven speed kept constant regardless of torque condition. Two sizes are offered — MCS-10-W, for motors of 7½ to 15 hp, has a minimum pitch diameter of 5.0 in., maximum of 10.0 in., and MCS-12-W, for motors of 15 to 20 hp, has a minimum pitch diameter of 6.0 in., maximum diameter of 12.0 in. T. B. Wood's Sons Co.

31—PROGRAM CONTROL records temperature variations

Model RCA is a pneumatic temperature program control which also functions as temperature recorder, and is reported particularly adapted in locations where steam is a heating medium. Described as a simple and rugged method for program controlling heating applications and providing sensitive proportioning valve operation, plus recording,



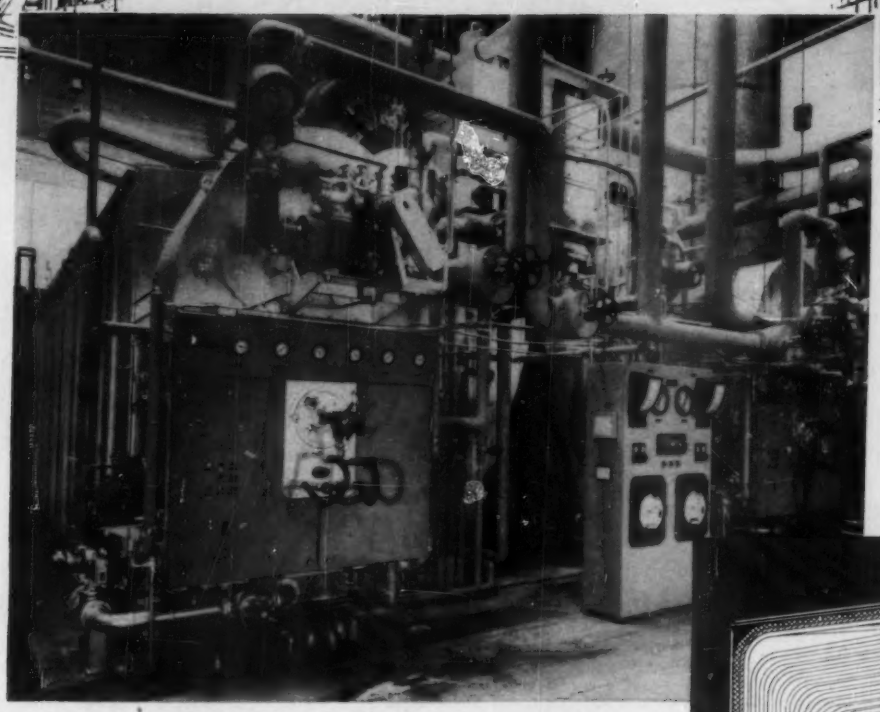
it comes in 10 optional temperature ranges between −30 and 1100 F. Designed to actuate an air-operated throt-

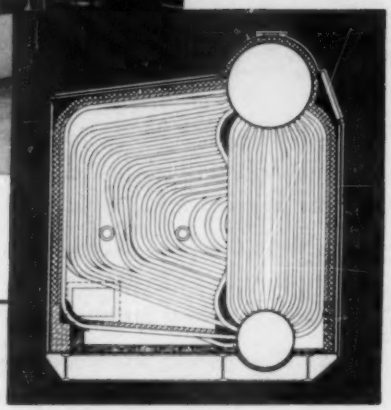
P·G and E·
Pacific Gas and Electric Company

KEELER dk package steam generators

...playing an important role in

SAN FRANCISCO'S CHANGING SKYLINE





PACIFIC GAS & ELECTRIC COMPANY'S "STATION T," San Francisco
one of two central heating plants operated by this progressive utility

Expansion and modernization engineered by PG&E staff

Design of plant addition and installation by BUMSTEAD-WOOLFORD CO., San Francisco

Several new, multi-story buildings are reshaping San Francisco's skyline. Their steam requirements are supplied by Pacific Gas & Electric Company's Station T, recently modernized for added steam generating capacity with the installation of two Keeler Type D K Package Steam Generators.

PG&E is aptly described as a true partner in California's growth—in fact, by most standards, it is the largest utility of its kind in the nation! In expanding its central steam plant operations, Keeler D K's were selected to enable the firm to keep pace with the increasing demands of its clients in the "new downtown area" served by Station T.

Each of the new D K's is a 55,000-lb. stm/hr capacity unit designed for 200 psi safe working pressure and combination oil-gas firing. They are providing PG&E with a nearly doubled gross steam output in essentially the same floor space as the old boilers which they replaced.

Flexibility, however, is the big advantage—a natural for a central steam plant with unpredictable and varying loads. The Keeler D K's are efficiently handling large load swings —quickly and with a stable water level.

Multi-purpose Keeler D K's are made in 24 sizes for gas, oil or combination firing in capacities up to 80,000 lb/hr. Write for full data . . . see for yourself why this popular D-type steam generator has earned a nation-wide reputation!

The Seal of Quality in Water Tube Steam Generators

KEELER WATER TUBE Boilers

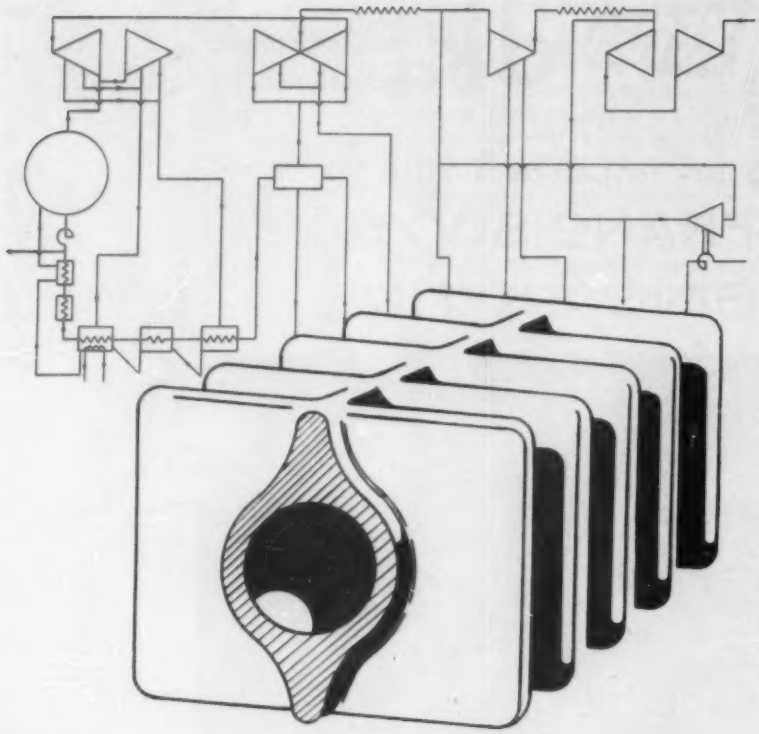
— ESTABLISHED 1864 —

Write For Bulletins

No. DK-2: Type DK Package Boilers
No. F-14: Type CP Boilers
No. M-2A: Type CPM Package Boilers
No. MK-1: Type MK Boilers

E. KEELER COMPANY
100-200 West St., Williamsport, Penna.
— OFFICES IN PRINCIPAL CITIES —
In Canada: Canadian Vickers, Ltd., Montreal, P. Q.

For more data circle 558 on Post Card



Green's Low-Level Economizer belongs on your steam cycle flow diagram!

Why has Green's Low-Level Economizer already been purchased for inclusion in several large units scheduled for operation in 1960, 1961 and 1962?

1. It is accepted that low-level heat recovery offers the most economic method of obtaining the lower heat rates required today.

2. Flue gas-to-water heat exchange transfers the low temperatures from the airheater to the Low-Level Economizer where the problems of corrosion and plugging can be adequately resolved.

Green has had over 100 years of economizer experience. It is yours for the asking.

Green

THE GREEN FUEL ECONOMIZER CO., INC.,

BEACON 3, NEW YORK

For more data circle 559 on Post Card

tling valve controlling the flow of steam, water or gas or to operate other air-operated devices, Model RCA is engineered for program control using a plastic cam cut (at factory or on the job) to desired temperature range. Several cams can be cut for the same instrument for different processes.

Also functioning as a temperature recording instrument, the control draws a line on paper charts showing variations in temperature. It is stated that in case of a failure of air supply, the valve will shut off, therefore shutting off the entire heat supply. A feature of Model RCA is that elements of same scale range are interchangeable, regardless of bulb type, permitting field replacement. Data in Bulletin 216. Partlow Corp.

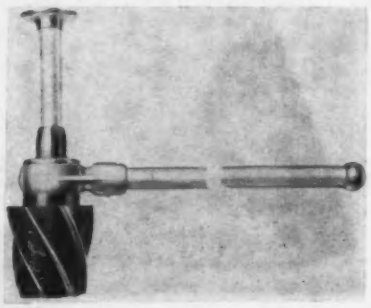
32—RELIEF VALVE doesn't chatter or hammer

The Hydro-Valve is designed specifically to be stable and non-chattering and provide full-rated capacity in liquid service. It will not drum, chatter, or

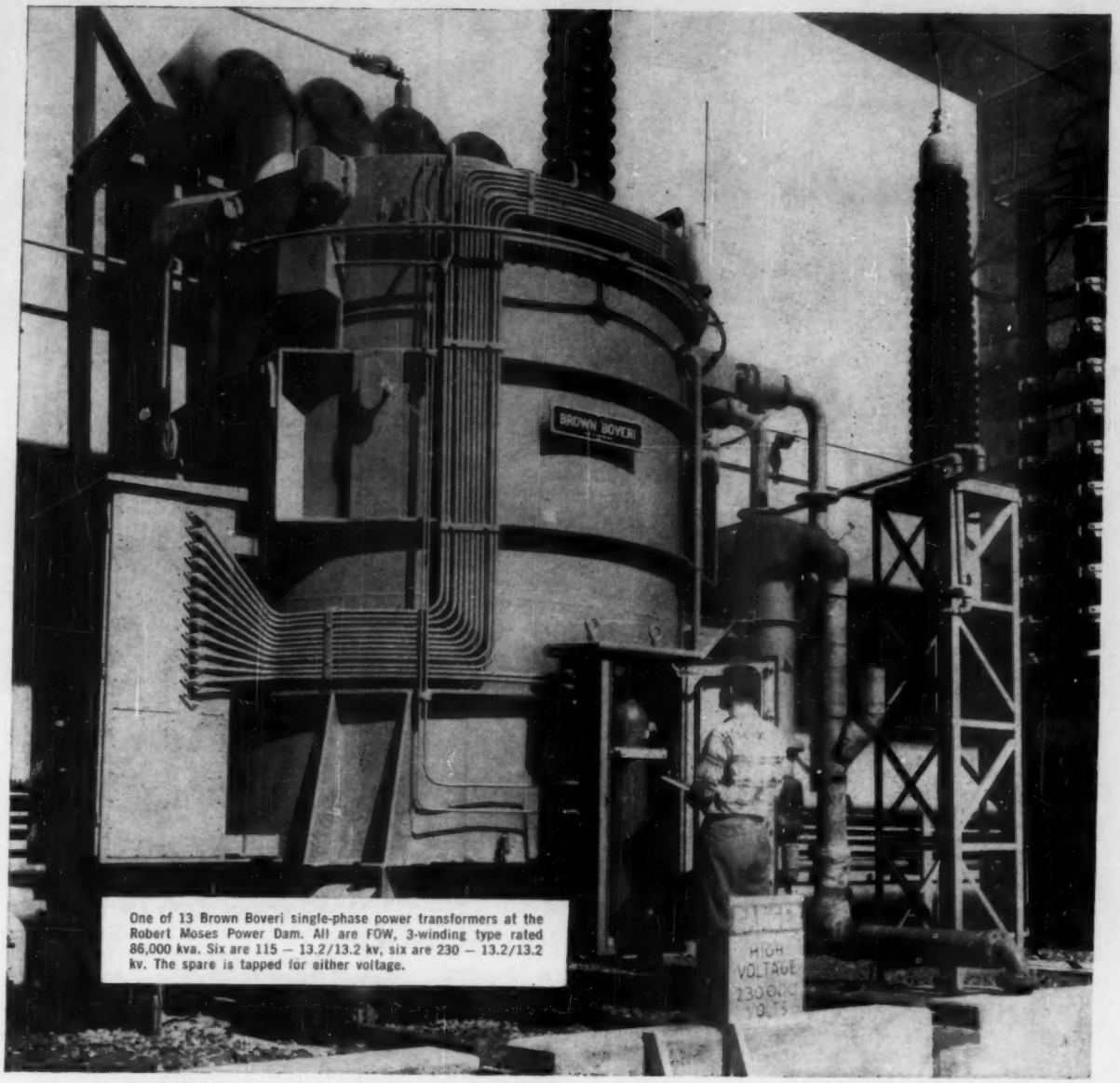
hammer on any application, company says, either bypass or emergency relief. The hammering is eliminated by a special design of the throat, seat, and baffle construction. Valve is available with a bellows if necessary to keep working parts away from contaminants, and corrosive or viscous fluids. Plain valve comes in sizes from 1 to 8 in., bellows version, 1½ to 8 in. J. E. Lonergan Co.

33—HAND REAMER for 3½- to 4-in. pipe, conduit

The No. 354 Spiral Reamer is designed to smooth the inside of 3½- to 4-in. pipe and conduit, and eliminate hand filing. Ratchet handle speeds work in



tight quarters, company points out, and seven spiral cutting edges pare off metal. Hand grip has large pressure plate. Hollow reamer construction reduces



One of 13 Brown Boveri single-phase power transformers at the Robert Moses Power Dam. All are FOW, 3-winding type rated 86,000 kva. Six are 115 – 13.2/13.2 kv, six are 230 – 13.2/13.2 kv. The spare is tapped for either voltage.

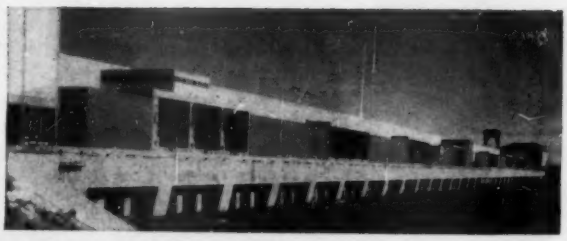
PHOTOS COURTESY OF N. Y. STATE POWER AUTHORITY

ALL'S QUIET AT MASSENA

You've heard the experts say it: Low noise means good design, tight construction. We agree. It's worth a trip to Massena just to hear the quiet around these Brown Boveri transformers.

Other features that can't be heard: the compact size, the light weight per kva, the high efficiency, the reliable service facilities . . . and the substantial dollar savings for a cost-conscious power producer.

Many of these features are due to Brown Boveri's exclusive radially laminated core. We'll be glad to give you full information about this core design and other features of Brown Boveri power transformers.



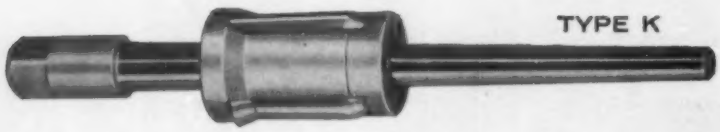
The Moses-Saunders Power Dam near Massena, N. Y., second largest hydro plant in the U. S. It was constructed jointly by the Power Authority of the State of New York and The Hydro-Electric Power Commission of Ontario.

BROWN BOVERI Brown Boveri Corp., Dept. PE12, 19 Rector Street, New York 6, N.Y. Agents in 27 U.S. cities.

For more data circle 560 on Post Card

write for your copy of this Bulletin!

ELLIOTT
Boiler Tube Expanders
for tubes 3/4 in. I.D. and up



This 16-page bulletin describes general types of Elliott boiler tube expanders for fast, efficient tube rolling jobs. It also gives dimensions, prices and other descriptive data and shows various drum, header and short series mandrels which are used with Elliott boiler tube expanders. Drum mandrels are seen with Type M and Type K above.

Accessories available to adapt Elliott boiler tube expanders to various tube rolling applications include universal joints and extension shafts, sockets, gear drives, etc. A new heavy-duty, right-angle gear drive utilizes roller bearings to minimize friction, cutting down power losses.

RIGHT-ANGLE GEAR DRIVE▸
Available in ½, ¾ and 1-in. sizes

Write the Elliott Company, Lagonda Division, Springfield, Ohio, *today*, for your copy of Bulletin Y-46.

Y7-9

ELLIOTT Company
For Tube Cleaners, Expanders and Accessories

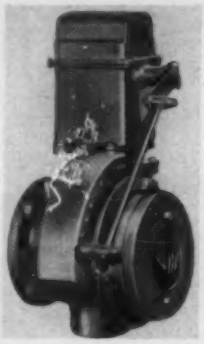
STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

For more data circle 561 on Post Card

weight for easy handling, and hardened tool-steel cone is removable for sharpening. The Ridge Tool Co.

34—PROPORTIONING VALVE, for manual or automatic use

Available in five sizes, these new Varitrols are designed to provide an economical two-in-one valve method of controlling air and gas to provide blending required for any firing condition. According to manufacturer, use of the Varitrol not only permits proper setting



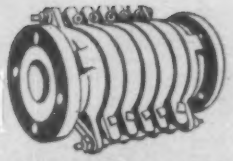
for the firing condition without trial-and-error adjustments, but also assures repeatability. Returning control arm to any position, manually or automatically, assures an air-gas mixture identical with previous settings, it is stated, and because Varitrols have nine gas-adjusting screws, the air-fuel ratio may be adjusted for each valve position. Electric or air-operated automatic controls may be used. Varitrols can be used to handle manufactured or natural gas, propane, butane, can supply multiple burners. Eclipse Fuel Engineering Co.

35—COMPRESSED AIR DRYER for small quantities

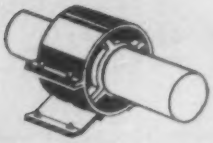
Designed for drying small quantities of compressed air, from 1 to 15 SCFM, with inlet pressures up to 125 psig and inlet temperatures up to 120 F, this inexpensive unit is announced as fully

automatic, using only a small amount of heat for reactivation. It has only two moving parts — a timer and a solenoid type four-way valve. Desiccant towers are replaced by breaking couplings, loosening screw, pulling out plug-in heaters and replacing with a new tower. Heaters are permanently imbedded. According to company, desiccant and heaters will last several years under normal

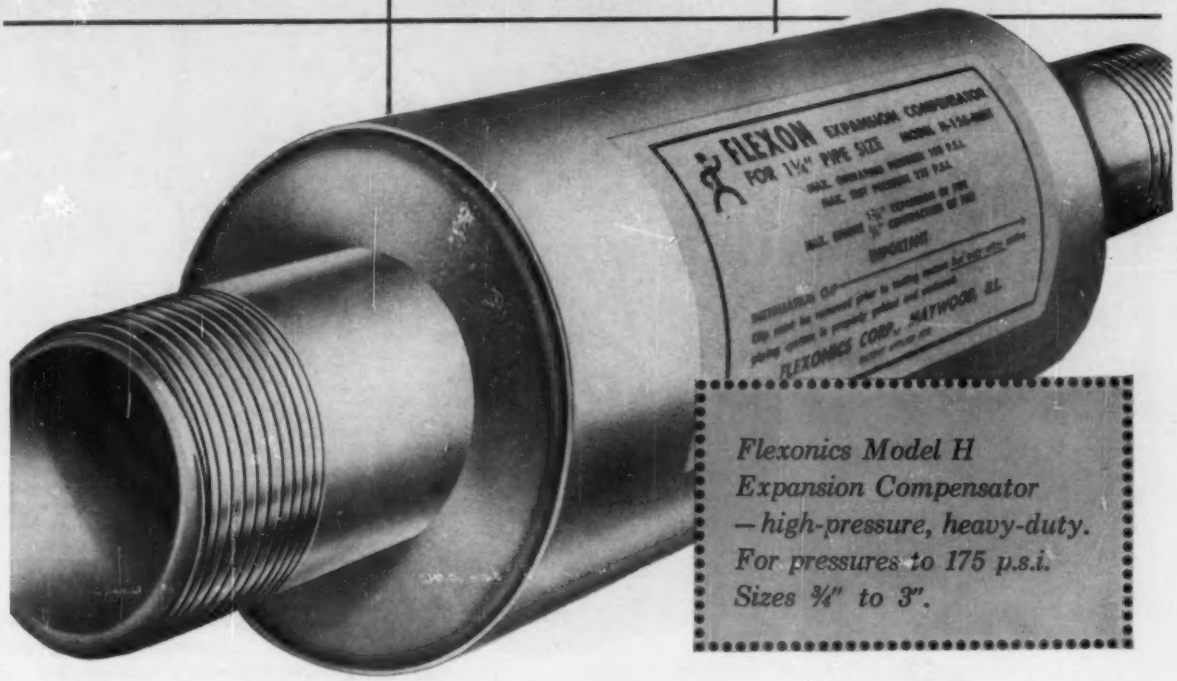
Flexonics Model L Expansion Compensator — to handle pipe and tubing motion up to ½" in low-pressure heating systems.



Flexonics Expansion Joints — controlled-flexing, free-flexing, and many special types, in an unlimited range of sizes.



Flexonics Pipe Guides — a completely new and better way to keep pipe in alignment. Positive, rugged, inexpensive.



Flexonics Model H Expansion Compensator — high-pressure, heavy-duty. For pressures to 175 p.s.i. Sizes ¾" to 3".

INCH FOR INCH, THE LOWEST-COST WAY TO TAKE UP PIPE EXPANSION

Any way you look at it, the Flexonics Model H Expansion Compensator *costs less* — costs less per-inch of stroke than any other way to handle pipe motion — costs less after it's installed because it never needs maintenance.

Yet the Model H is built for hard service. Its 2-ply stainless steel Flexonics bellows is designed to outlast the building. Steel-encased and heliarc welded for full protection from external damage. Positive internal guide and anti-torque device. Completely packless. No servicing necessary after installation.

These are the reasons why engineers and piping contractors are specifying the Flexonics Model H for thousands of industrial piping jobs that use pipe up to 3" and require up to 2" total movement at each Expansion Compensator. Working pressures to 175 p.s.i. for ¾" and 1" sizes; to 125 p.s.i. for larger sizes up to 3".

Make the Flexonics Model H Expansion Compensator a cost-cutting part of your next piping job.

Today—write for informative and helpful Catalog No. 163R.

EC-130

TOMORROW'S ENGINEERING TODAY

Flexonics

EXPANSION COMPENSATORS

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For more data circle 562 on Post Card

RETURN LINE CORROSION *Can* BE LICKED!

Drastic reduction of return line corrosion in an easy, effective and economical way has been the unanimous experience of hundreds of plants throughout the country using Bird-Archer's Amine Treatment.

A plant in New York State, generating approximately 500,000 lb. of steam a day, had a normal condensate pH value of 6.3 that resulted in almost constant piping replacements. Only 6 lb. per day of Bird-Archer's Amine Treatment cut maintenance costs to a new low by raising the pH value to the safe range of 8.0 to 8.5.

A plant in New England, generating 600,000 lb. of steam a day, did not have an open feedwater heater which would mechanically eliminate the exceedingly high CO_2 content of their makeup water, consequently, the pH value of their condensate was sometimes as low as 5.9. Less than 12 lb. of Amine Treatment a day raises the pH value of the condensate to 8.5, eliminates excessive corrosion.

After two years of experience with Amine Treatment a power plant in Massachusetts, making 250,000 lb. of steam a day, enthusiastically reports that they eliminate over 75% of their piping replacements through the use of only 2 or 3 lb. a day of Amine Treatment.

Return line corrosion has been licked at these plants. Let a Bird-Archer Service Engineer help you solve *your* corrosion problems.

Write for Bulletin CP100 and the name of the Bird-Archer Service Engineer nearest you.

BA-801

BIRD-ARCHER

WATER TREATING CONSULTANTS

The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa.

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The BIRD-ARCHER Co. of California, 415 Brannan St., San Francisco

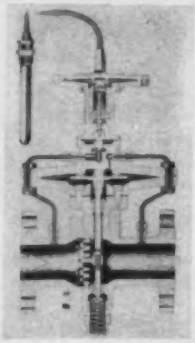
Offices in Canada and Mexico

For more data circle 563 on Post Card

operation. Built-in dust filters are designed to assure clean, dry air at dew points to −60 F or below. Uses include air supply for controllers and instruments. Desomatic Products, Inc.

36—CONTROL VALVE regulates temperatures

This pilot operated temperature control valve features self-cleaning seats, linear flow curve, integral pilot with filter screen and oversize, clog-resistant



passages. Short stroke with metal seats and metal diaphragms is designed to give long life with minimum maintenance. Seats are self-lapping for tight shut-off. The unit controls temperatures from 35 to 450 F, with only ten ranges. It comes in sizes 2½ and 3 in., has cast-iron flanged body, 125- or 250-psi ASA connections. OPW-Jordan.

37—PLASTIC NOZZLES for corrosion-free service

For use wherever a non-metallic, corrosion proof nozzle is required, these PVC nozzles are claimed to be non-clogging and long wearing. Made from

one piece of PVC using company's spiral design, the valves are available in 28 models with wide or narrow angle, full or hollow cone and seven flow rates from 2 to 70 gpm. Prices range from around $2.00 to $5.00 each. Bete Fog Nozzle, Inc.

38—MICA MAT TAPE doesn't need varnish or baking

This mica mat tape requires neither varnish nor bake treatment during application, company says. An all-purpose, form-wound insulator, it is expected to find wide application in motor repair shops where it eliminates necessity for stocking several grades and sizes of insulating tape. Engineers say "dry" application is made possible by tape's extreme flexibility and uniform thickness which allows it to conform to surfaces in void-free layers. Tape uses four-layer construction that sandwiches ribbons of mica mat and glass cloth between two outside films of Mylar polyester insulation. General Electric Co.

Aerovent FANS

Checking specifications and comparing notes prior to "blast-off" of unit #3 at Astoria Generating Station, Long Island, New York.

built BIG for a BIG job at Con Edison

Inspecting three of a total of 24–84" Duct Fans recently installed at Consolidated Edison's new Arthur Kill and Astoria, New York Generating Stations are a member of Con Edison's Engineering Staff and D. J. Citron, New York area representative for Aerovent.

Twelve units, rated at 100,000 cfm each, provide a total of 1,200,000 cfm to draw heat from boiler plants in both locations. In addition, eight 32" Panel Fans, rated at 10,000 cfm each, cool turbine rooms at each station. That's cooling – KING SIZE!

Write for Bulletins 100 and 151

Air deliveries of Aerovent equipment determined in accordance with established and accepted codes and guaranteed by manufacturer.

CERTIFIED PERFORMANCE

Aerovent

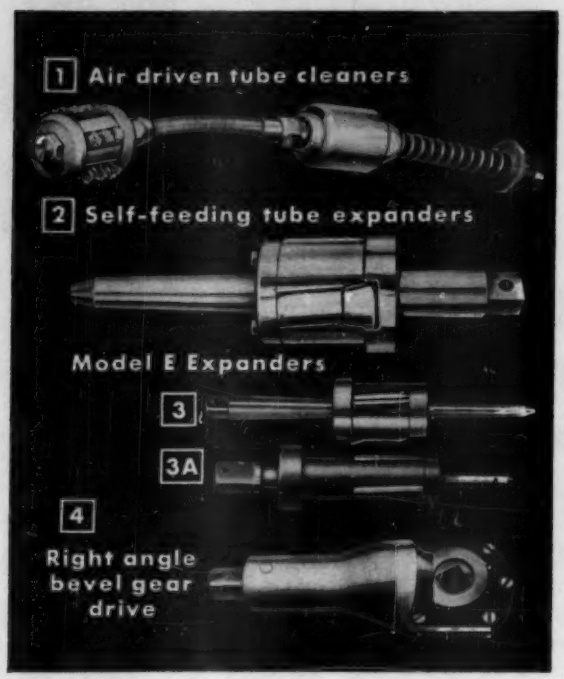
FAN COMPANY, INC.

Ash and Brush Streets — Piqua, Ohio

Consolidated Edison's new Arthur Kill Generating Station situated at Staten Island, New York.

For more data circle 564 on Post Card

Keep boilers on the line with WILSON TUBE MAINTENANCE TOOLS



1 Heavy-duty air driven tube cleaners are designed to deliver maximum power at the most efficient cutter head speeds while negotiating sharp bends, the Model ECT Air Cleaners are excellent for cleaning curved boiler tubes from 2½" to 4½" O.D.

2 Wilson Model 38 tube expanders are self-feeding and parallel expanding. They are of the single flare roll type. Available for tubes 1" O.D. to 4½" O.D. with various roll lengths for tube seats ¾" and up.

3 Flaring type expander 1" O.D. to 4½" O.D. tubes, ½" to 2" tube seats.

3A Long reach type expander 1" O.D. to 4½" O.D. tubes, 2½" to 5" tube seats.

4 This Wilson bevel gear drive is expressly manufactured to meet continuous and heavy duty service conditions. The one piece all steel body is extremely rigid and not subject to distortion. The maintenance of perfect gear alignment is assured with consequent long service life.

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88. TW-882

Representatives in principal cities

THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

WILSON

TUBE CLEANERS • TUBE EXPANDERS

For more data circle 565 on Post Card

sheets and other information.

Refractory insulating concrete stops stack corrosion

This gun-applied lining of refractory insulating concrete bonded with LUMNITE calcium-aluminate cement is providing dependable protection to stacks at United Illuminating Company, New Haven, Conn. Such linings resist corrosive action of flue-gas condensate forming on stack surfaces.

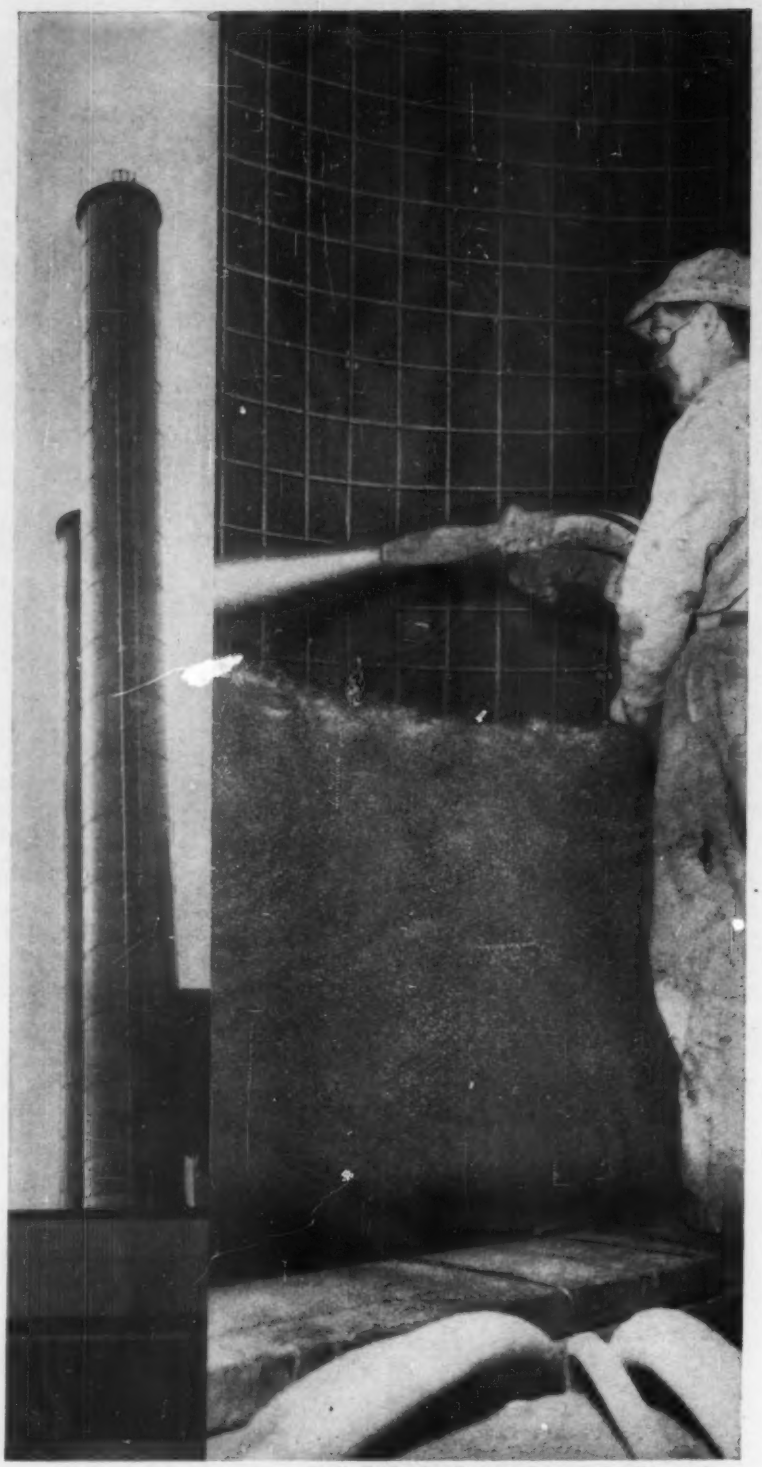
Furthermore, the concrete retains high strength under continuous exposure to heat as well as frequent heating-cooling cycles.

Installation is fast, easy, economical. Linings can be cast in place, plastered or "gunited." Service strength is reached in 24 hours.

For added convenience and economy, there are castables made with LUMNITE cement – packaged mixtures ready for use with just the addition of water. They're available from leading manufacturers of refractories.

For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

"USS," "Atlas" and "Lumnite" are registered trademarks.



Gunite Contractor: Pressure Concrete Co., Newark, N. J.

Universal Atlas Cement
Division of
United States Steel

L-194

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ELECTRICAL EQUIPMENT

201 Electrical Enclosures — Bulletin EE, 14 pp, describes company's line of sheet metal electrical enclosures and other related items for a variety of applications. Covers control desks, electrical cabinets and enclosures, power distribution and control panels, boiler, turbine generator control panels, switchgear housings, and others. The Kirk & Blum Mfg. Co.

202 Cable Troughs — This 28-pp catalog offers a simple solution to any design problem of change of direction or elevation with a complete set of standard fittings, horizontal elbows, inside and outside vertical elbows, ties, crosses, covers and special devices. The Globe Co.

203 Handbook on Fuses — This 12-pp booklet contains practical information on how to get safe, dependable, trouble-free electrical protection. Shows what to do when fuses blow, how to determine cause of blows, what kind of fuse to use for various circuits. Contains short history of fuses and notes on construction of fuses. Bussmann Mfg. Co.

MECHANICAL POWER TRANSMISSION

206 Worm Gear Reducers — Complete horsepower and torque data for company's worm gear units built on 2½ up to 4-in. centers are given in full-page tables in Bulletin 5018. Dimensions are diagrammed and tabulated in detail, and materials and design of interchangeable components are described. De Laval Steam Turbine Co.

210 Spring Clutches — Described in this 30-pp catalog are five standard lines of spring clutches in bore sizes from ⅛ to 1 in., torque capacity to 1250 lb-in., for use in applications utilizing drive up to 5 hp. Clutches offered include over-running and back-stopping; indexing; on-off; on-off indexing; and safety lock control. Catalog lists specifications and provides technical and application data, illustrations. Marquette Div., Curtiss-Wright Corp.

INSTRUMENTS, CONTROLS

214 Metering Control Systems — Bulletin 500 describes purpose, design and operation of company's metering and control systems. Includes discussion and pneumatic and electric telemetering and pneumatic control, along with detailed literature references. Bailey Meter Co.

217 Controls Data—Comprehensive data on all types of controls, including diaphragm valves, pilot controllers, regulators, safety heads and tank vents are presented in this loose leaf notebook.

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Individual sections contain all pertinent information on each specific product, including descriptive details and engineering data, dimensions, specifications. Application and operation details are fully illustrated. Black, Sivalls & Bryson, Inc.

219 **Guide to Gages** — Catalog 300-B, 112 pp, features Ashcroft, Dura-gauges, Maxisafe, pneumatic receiver, recording, quality, drawn case, chemical and special application gages. Also presented are gage testers, pneumatic transmitters, gages for nuclear energy. Engineering data and charts are provided. Instruments shown cover dial sizes from 2 through 24 in. Manning, Maxwell & Moore, Inc.

223 **Water Columns, Gages** — Featured in Bulletin 516B are boiler water columns and gage equipment. Illustrates and describes water columns for all pressures, as well as remote reading gages, liquid level alarms, water gage illumination equipment, and electrode-type liquid level alarms. Reliance Gauge Column Co.

224 **Pressure Gages** — Featured in 46-pp Catalog 1000G is a line of pressure indicating and vacuum gages for a variety of industrial, chemical, and refinery applications. Selector tables give detailed data on various gages and recommended service applications. Specifications, standard graduation tables, photos and dimensional diagrams are included. J. E. Lonergan Co.

225 **For Feedwater Analysis** — Bulletin 148BP contains a technical discussion of manufacturer's analyzers for determination of dissolved oxygen and hydrogen in feedwater. Discusses both O and H units as to function, ranges, accuracy. Cambridge Instrument Co., Inc.

226 **Feedwater Regulator** — Bulletin 1044 describes a feedwater regulator designed for boilers carrying reasonably steady loads at steam pressures from 10 to 785 psig. Specifications are included, as well as flow diagram and cutaway views showing details of operation and design. Copes-Vulcan Div., Blaw-Knox Co.

227 **Industrial pH Equipment** — Eight-pp Bulletin 5400 gives detailed descriptions and specifications for industrial pH instruments, electrodes and accessories manufactured by the company. Brochure is profusely illustrated with photos and detailed drawings. Process Instruments Div., Beckman Instruments, Inc.

228 **Oil Leak Detection** — Eight-pp illustrated Bulletin 80, on the Paraprobe oil leak detection system for steam-type fuel oil heaters gives a detailed explanation of the operation of the system. Provides installation diagrams, standard specifications, explains determination of condensate flow rate. Davis Engineering Corp.

229 **Ion-Exchange Controls** — Bulletin E-158 describes automatic control systems for ion-exchange equipment. Standards designed to assure proper performance of control units are detailed, and various elements in the control cabinets, as well as the power-operated units, are described. Specifications for electrical controls are also included. Illinois Water Treatment Co.

230 **Temperature Regulators** — Six-pp Bulletin 1012 describes company's line of steam regulating valves with pilots

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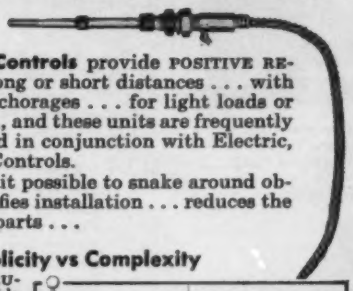

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Flexibility makes it possible to snake around obstructions . . . simplifies installation . . . reduces the number of working parts . . .

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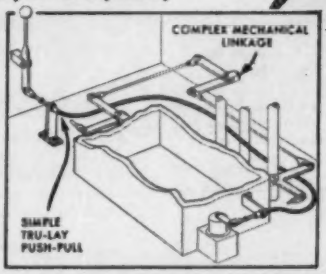
Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Positive Remote-Action and Flexibility, together with Precision and Long Life, explain why TRU-LAY PUSH-PULLS serve designers and users equally well in improving machine operations, whether the application is on such severe service jobs as Bulldozers, Power Shovels and Steel Mill Machinery, or on such light duty work as Photographic Equipment, X-Ray or Business Machines.

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Complete Protection Against Dirt and Moisture is a big factor in the use of this unit on machinery in Coal Mines, Cement and Steel Mills, Oil Fields and in many other industries.

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Lubrication of the inner working member is for life.

Temperatures as low as —70°F will not hinder the proper operation of this unit, and it is thoroughly effective even in the extreme high temperatures encountered on Jet Engine, Furnace Door and Glass Furnace Damper control applications.

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...a unique feature of Beckman Oxygen Analyzers. It gives paramagnetic measurements—specific for oxygen—for continuous combustion control with minimum maintenance. It's shock-mounted, vapor sealed, thermally insulated and thermostatically controlled. ⌘ Highly accurate even under the most demanding industrial applications, the sturdy dumbbell enables these analyzers to give you dependable results in just seconds. No extra components for extra maintenance. Read percent oxygen directly off the indicating meter or accessory recorder. ⌘ A wide variety of sampling accessories is available. Write for Data File 78-12-08.

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Write for Bulletins —No. 851 on Cause, Effect and Control of Water Hammer. No. 654 on Valves.

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for both fast and slow heating exchangers. Selection tables and line drawings of typical applications are also included. Spence Engineering Co., Inc.

231 Ideas on Push-Pull Controls — Included in this "Idea File" are answers to a power engineer's questions on the use of push-pull controls. A general information booklet discusses remote control applications, explains construction and operation of company's Tru-Lay controls. Separate bulletins are devoted to standard assemblies, bracket-type head controls. Automotive and Research Div., American Chain & Cable Co., Inc.

DUST CONTROL

233 Dust Control Unit — Featured in Bulletin V-100 is a conditioner unit for dust control, designed to apply rapid, on-the-spot conditioning to dust materials in all types of handling. Principles of operation are described in an accompanying engineering data bulletin, Bulletin V-101. The Johnson-March Corp.

234 Precipitation Products— Twelve-pp Bulletin G406 contains helpful information on company's various precipitation products, including electrical precipitators, multiclone mechanical dust collectors, combination multiclone-precipitator units, Dualaire filter-type dust collectors and Holo-Flite processors. Also illustrates installations. Western Precipitation Corp.

VALVES, TRAPS, AND PIPING

235 Industrial Valves — Condensed Catalog 105, 28 pp, contains data on valves for a wide variety of applications. Includes dimensions and illustrations, describing non-return (stop check) valves, globe and angle stop valves, pressure seal design, angle univalves and small size globe valves designed for chain or extension operation in vertical lines. Edward Valves, Inc.

236 Silent Check Valves—Described in Bulletin WH-654 are silent check valves featuring low frictional resistance. Tables list dimensional data and reasonable velocities for flow of water through pipe, fittings and valves. The Williams Gauge Co., Inc.

238 Diaphragm Control Valves — Three basic types of single seated diaphragm control valves are illustrated and described in 16-pp Bulletin 5304. Covers design and construction features, and includes materials tables, capacity data, and specifications. Leslie Co.

239 To Get at Those Valves — This little folder describes a sprocket rim with chain guide. The rim adjusts to fit all valve wheels. Babbitt Steam Specialty Co.

241 For Lightest Condensate Loads — Bulletin T1744 (58) describes company's No. 30 impulse steam trap for use where condensate must be handled in very small amounts. Lists advantages and applications, tells how trap works and gives capacities, dimensions, materials used, prices. Yarnall-Waring Co.

242 Steam Trap — Bulletin 257-B describes a steam trap which uses the kinetic energy of steam to close the valve. Features of trap are detailed, and dimensional data included. Sarco Co., Inc.

243 Steam Trap Book — Catalog K, 48 pp, is a manual of steam trapping prac-

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KO9...the amazing electric motor cleaner. Simply immerse the running motor in *KO9*, remove it minutes later as clean as new.

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with Chain Guide

CHANGES THAT DANGER ZONE TO A SAFETY ZONE

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Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
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- They save time and money.
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- A hot-galvanized rust proof chain is available for all sizes.

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OXYGEN
in the feedwater

HYDROGEN
in the steam

OXYGEN is well known to be an active source of boiler corrosion. The oxygen dissolved in feedwater is determined directly and continuously recorded upon the Cambridge Dissolved Oxygen Recorder.
The oxygen set free by dissociation of the water in the boiler is equally damaging. Its presence is determined by measuring the free hydrogen in the steam condensate. Cambridge Analyzer-Recorders provide continuous records of both the oxygen dissolved in the feedwater and the hydrogen in the steam — on one chart if desired, thus enabling prompt corrective measures to be taken.

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A.S.T.M. BULLETIN D1586-58T

Describes the approved referee method of testing for gaseous hydrogen in industrial water.

CAMBRIDGE Bulletin No. 148 BP

Describes both the CAMBRIDGE Dissolved Oxygen and Dissolved Hydrogen Analyzers.

Instrument shown may be used to record either O_2 or H_2 or both simultaneously. Cambridge also makes Hydrazine Analyzers, PH Recorders and instruments for analyzing gaseous mixtures.

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- to remove O_2
- reduce oxides
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Fairmount DEOXY-SOL, a solution of hydrazine, is a high efficiency oxygen scavenger designed especially for high pressure boiler water treatment.

DEOXY-SOL removes oxygen, reduces oxides and raises pH of the condensate all at the same time . . . yet adds no solids.

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tice. It includes a section giving physical data and prices on OF&T traps, cast semi-steel and forged steel inverted bucket steam traps, compound traps, ball float air and air relief traps. A handbook section explains how to calculate condensate load, and select traps for all classes of equipment; a maintenance section explains trap installation, testing, and maintenance. Armstrong Machine Works.

246 Flexible Hose, Bellows — Sixteen-pp Catalog 187 describes applications and use of flexible metal hose and bellows. Engineering specifications and sizes, pressure ratings, materials and fitting attachments are included. Detailed drawings and pictures facilitate specifications of individual applications. Flexonics Corp.

BOILERS, GENERATORS

250 Fire Tube Boilers — This 12-pp catalog describes Superior Compact packaged boilers in capacities from 20 to 200 bhp. Interesting arrangement of test, illustration and color is used to explain many features. Gives dimensions for boilers designed for firing oil or gas or both. Superior Combustion Industries, Inc.

251 Package Boilers — This 12-pp booklet on package steam generators describes the formulas behind all package steam generators, and illustrates how installation of a package steam generator can raise steam capacity in an existing boiler room. Cyclotherm Div., National-U. S. Radiator Corp.

252 Hot Water Boilers — This 20-pp Brochure HCC-2 describes and illustrates design, construction, advantages and economics of the C-E La Mont controlled circulation hot water boiler for supplying high pressure, high temperature water for heating systems and process uses. Combustion Engineering, Inc.

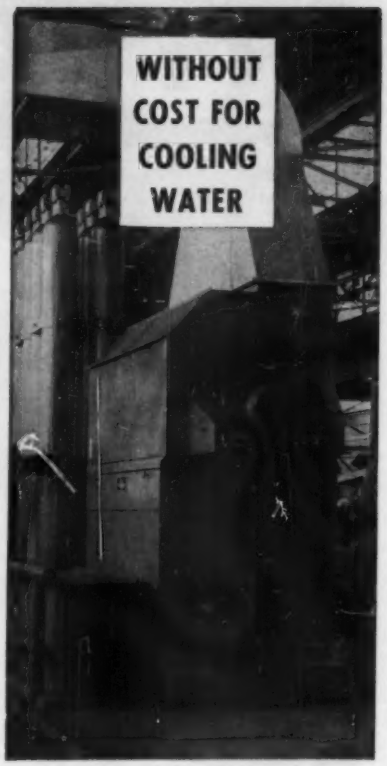
253 Boilers for Many Services — This general product data catalog contains detailed literature on the company's line of boilers for heating, power and process steam. It contains separate data sheets for each product, including high pressure and low pressure boilers, boiler-burner units and water heating equipment. In addition to photos and diagrams illustrating design and operation features, it provides tabular engineering data. Industrial Div., American-Standard.

254 Steam Generators—Bulletin PSG-3 describes design and construction features of company's package unit steam generator, a vertical bent tube, longitudinally fired water tube boiler. Capacities, dimensions and weights are given. Henry Vogt Machine Co.

255 Packaged Generators — Booklet PG-58-2, on packaged steam generators, covers features, standard and optional equipment, capacities and dimensions. Foster Wheeler Corp.

256 Integral-Furnace Unit — Bulletin G-94 describes the Type PFI integral-furnace boiler, a pressurized-furnace oil- and gas-fired steam generator for power, process or heating loads requiring steam capacities to 400,000 lb-hr at pressures to 1150 psi and temperatures to 900 F. Includes information on membrane wall. The Babcock & Wilcox Co.

257 Packaged Generators — Bulletin MH 3-54, 14-pp, gives detailed cover-



ACCURATE TEMPERATURE CONTROL of Hydraulic Liquids PREVENTS LOSSES

• This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

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age to company's Type MH packaged water tube steam generators which are finished for oil or gas firing or both, with automatic, semi-automatic, or manual controls. Included are: cutaway illustrations, installation photos, tube arrangement layouts, construction details, auxiliary equipment, dimensions. Union Iron Works.

TUBING AND ACCESSORIES

258 Tubes and Plates — Publication B-2, 46 pp, covers the subject of tubes and plates for condensers and heat exchangers. Field of application and particular problems encountered in each are described. Information on condenser tube alloys, plates for tube sheets and baffles, manufacturing methods, installation, operational factors affecting tube life, corrosion factors in condenser tube service is presented. The American Brass Co.

260 Tube Cleaners — Bulletin G-515 describes company's line of air, steam and water driven tube cleaners and accessories. Photos of the various types of cleaners are included, along with descriptive details and specification data. Elliott Co., Roto Plant, Div., Carrier Corp.

261 Tube Cleaners, Expanders — Eight-pp Catalog R53C describes a line of tube cleaners, tube expanders and portable pneumatic tools. Features and advantages are fully illustrated and specification data included. Thomas C. Wilson, Inc.

COAL AND ASH HANDLING

262 Shredders, Crushers — Bulletin 257 describes and illustrates hammermills and shredders, rolling ring and special crushers for reducing chemicals, minerals, ceramics, and other materials including wood waste. Discusses construction features. American Pulverizer Co.

263 Coal Crusher — Factors to consider in selecting a coal crusher for a particular operation are detailed in 12-pp Bulletin 154. Types of coal crushers and advantages of each are described and capacity and specification data included. Gruendler Crusher & Pulverizer Co.

264 Hydraulic Shakeout — Bulletin 658 describes and illustrates the Carquake, hydraulically powered car shakeout designed for maximum car shaking with minimum noise. Rail- and stationary-mounted types are shown. Six advantages detailed. Stephens-Adamson Mfg. Co.

REFRACTORIES

265 Refractory Castable — Bulletin R-40 describes the use of Kaocrete, company's refractory castable, in boiler ashpits. A discussion of the various methods of ash removal, along with the maintenance problems peculiar to each, is presented. Four installations detailed. Refractories Div., The Babcock & Wilcox Co.

266 Refractory Mortar — This is a 24-pp manual covering the use of Lumnite calcium-aluminate cement as a mortar mix for gun-applied linings in power plant, refinery and metalworking equipment. Includes data on mortar preparation, placing procedures, curing; also information on use of Lumnite cement as a masonry mortar for laying brick. Universal Atlas Cement Div., United States Steel Corp.

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- DEAD END SHUT-OFF
- WIRE DRAWING MINIMIZED—or eliminated
- SELF-LAPPING SEAT
- NO HUNTING—SHORT STROKE FOR IMMEDIATE RESPONSE

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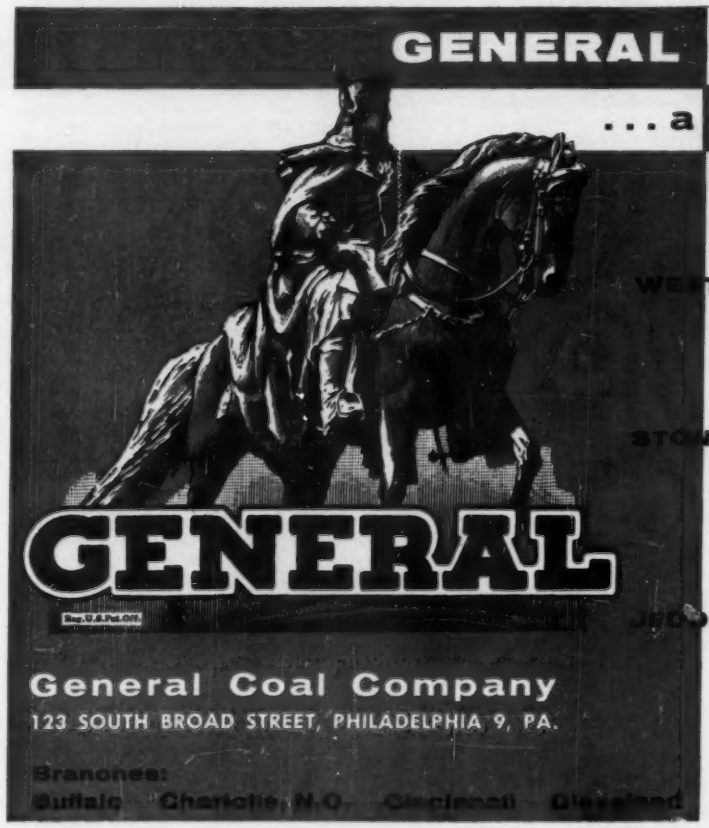

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FUEL BURNING EQUIPMENT

267 Water-Cooled Stoker — Design and operating advantages of the Vibragrate Stoker are outlined in this illustrated bulletin. A large cutaway view details component parts of the stoker and explains operating features. Other drawings show installations. American Engineering Co.

268 Oil and Gas Burners — Bulletin OB-53, 28 pp, gives principles of selection and application of oil or gas burners, or a combination of both for standard and wide capacity range operation, together with air registers and fuel oil heating and pumping sets. The Engineer Co.

269 For Burning Refuse Fuel — This 8-pp bulletin describes refuse fuel burning equipment, including a pneumatic refuse fuel distributor which spreads refuse fuels such as bark, wood chips, and bagasse uniformly over the grate surface. Discusses various components. Riley Stoker Corp.

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WATER CONDITIONING

275 pH and Chlorine Control — The 14th, 1959 edition of company's handbook, "Modern pH and Chlorine Control," 100-pp, incorporating theory and practice of colorimetric analysis, serves as a reference for quantitative determination of pH, chlorine, phosphate, nitrate, sulfate, hardness and other tests. Slide comparators and complete test kits are illustrated. In addition to standard pH determinations, methods are outlined for quantitative analyses of phosphate, calcium, magnesium, silica, nitrate, hardness. Available to qualified power engineers, please state your job title. W. A. Taylor Co.

276 Coagulant Aids — Featured in this product bulletin is a line of coagulant aids designed to improve floc formation in clarifying and softening water. Advantages are detailed and typical applications described. Calgon Co., Div., Hagan Chemicals & Controls, Inc.

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279 Feedwater Treatment — Process Bulletin B1, "Treatment of Boiler Feedwater by Direct, or Internal Method," discusses advantages of direct treatment, as a complete treating program or as a supplement to external systems. Explains why direct treatment is convenient, economical. Nalco Chemical Co.

280 Boiler Water Treatment — Chemical reduction of oxygen in boiler feedwater with hydrazine is the subject of 10-pp Bulletin BW. Economy and operation, handling of the Deoxy-Sol, methods of analysis and other details are covered. A bibliography lists supplementary reading. Fairmont Chemical Co., Inc.

282 Deaerating Heaters — Twelve pp Bulletin WC-106A on tray type deaerating heaters covers principles of deaeration, tray heater operation, standard heater design and applications, accessory equipment, and design and fabrication of tray utility heaters. A section on design features discusses load variations, installation, metallurgy and construction of trays. Graver Water Conditioning Co.

HEAT EXCHANGES

283 Heat Exchangers—Bulletin 132 contains detailed information on company's self-contained heat exchanger featuring sectional design. Cutaway diagram shows heat exchanger functions. Niagara Blower Co.

284 Heat Exchanger — Featured in this 12-pp bulletin is the Fin-Pak, a compact heat exchanger designed for a wide variety of fuel burning and process equipment. Structural details and operating principles are illustrated and typical installations shown. The Air Preheater Corp.

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288 Organized Lubrication — Benefits of organized lubrication — major cost control factor — are extolled in this 24-pp bulletin. Cost control opportunities are detailed and the task of assigning responsibilities and delegating authority in an organized lubrication system discussed. Method of determining savings and setting up records to measure results is also covered. Texaco.

290 Pipe Insulation — Featured in brochure J-432 is a lightweight, flexible, one-piece pipe insulation composed of incombustible, moisture-resistant mineral wool fibers, bonded with a phenolic resin and molded into 6-ft long sections. Characteristics of the material are described. Baldwin-Ehret-Hill, Inc.

295 Retracting Blowers — Design and construction details on company's 300 IK Long Retracting Blowers are illustrated and described in 12-pp Bulletin 2111. Photos and diagrams showing component parts are included. Diamond Power Specialty Corp.

297 Cranes, Hydro Equipment — Twelve-pp Brochure HY-51 describes cranes and equipment for hydroelectric, water supply and other applications. Various components and assemblies that help harness hydroelectric power are pictured, including cranes and hoists, gates and valves, and special hydroelectric equipment. Yuba Consolidated Industries, Inc.

298 On Model Studies — Advantages of model studies for precipitators and other gas handling systems are presented in this 18-pp brochure. Discusses three plans under which this new engineering service is available. Several case histories are detailed to show benefits obtained. Also provided are articles on the subject reprinted from POWER ENGINEERING and other publications. Research-Cottrell, Inc.

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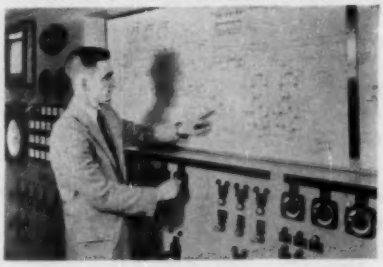

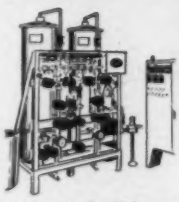

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